Materials in Design Engineering

UNIVERSITY OF MICHIGAN
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ENGINEERING

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

A New Look at Nylon Plastics

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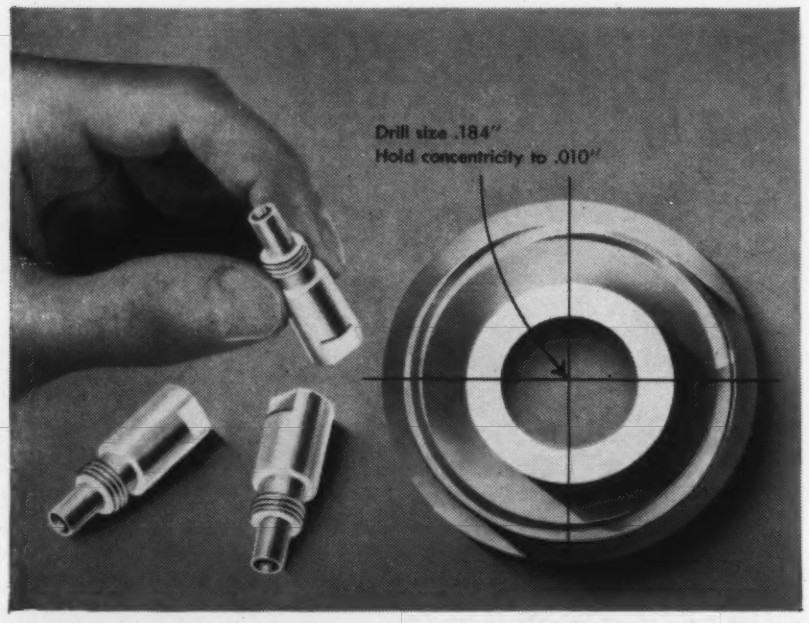
DECEMBER, 1958

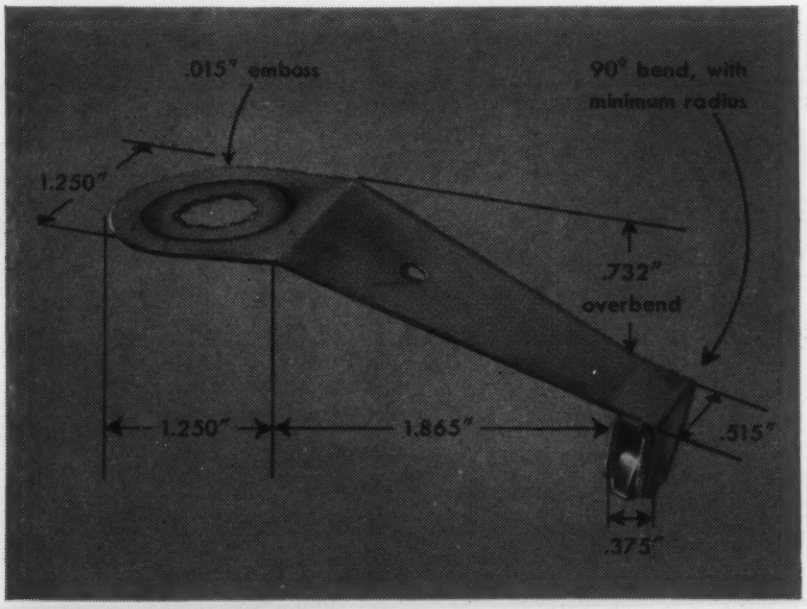
Also: Coextruded Parts A Guide to Ferroelectric Ceramics Complete Contents – p 1

THE RIGHT METAL often costs less, may give you surprising savings in fabricating time and cost. Talk to the Man from Anaconda about matching metals to your specific needs, today.



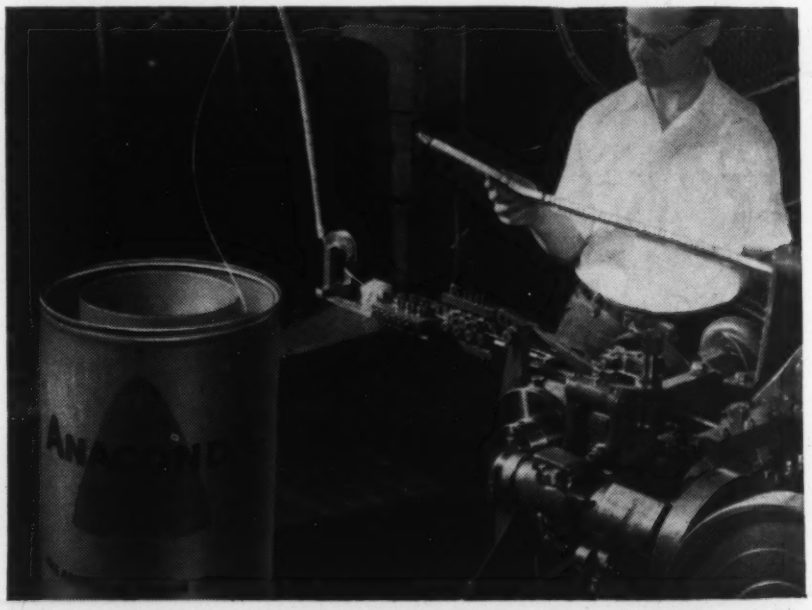
BRASS ROD WITH A SLIGHTLY HARDER CORE than standard rod eliminated rejects (that had run up to 15%) for M. J. Grass Screw Machine Products Co., Buffalo. With standard rod, in drilling a deep hole on multiple spindle machines, the drill tended to wander past the concentricity tolerance.

LEADED COPPER STRIP (machinability rating 80%; conductivity, 99% IACS) boosted production, cut over-all costs 25% for Truelove & Maclean, Waterbury, Conn., in making power transistor bases. Adequate production with ordinary electrolytic copper would have called for new equipment investment.



SUPERFINE-GRAIN PHOSPHOR BRONZE eliminated fractures in forming complex variable voltage tap springs (above) used in Lionel's Trainmaster transformers. Lionel had considered substituting a costlier alloy but Duraflex* did the job at no extra cost.

*Anaconda superfine-grain phosphor bronze.



PAY-OFF BARRELS with big coils of brass wire cut down-time 90% at wire forming machines for West Haven (Conn.) Buckle Co. Machines making surgical buckles had used light coils for free pay-off; new coils had to be fed in about every hour.

FROM a base of 93 standard alloys, The American Brass Company can provide an almost unlimited number of combinations of useful properties. It may take only a minor variation in fabrication or annealing in your present alloy to make the metal fit your need exactly. Or you may need another alloy—perhaps one that is less familiar to you because it has had such highly specialized application. So when new or unusual problems arise, ask for the help of our Technical Department. See your Anaconda representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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Materials
in Design Engineering® *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

DECEMBER 1958
VOL. 48, NO. 7

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COVER BY HARRY & MARION ZELENKO

Diver wields Monel "vacuum cleaner" in one of the world's most ticklish jobs

This photograph was taken in a ½-million-gallon tank at Miami's fabulous Seaquarium.

Here they have sharks . . . barracuda . . . moray eels . . . porpoises . . . manta rays . . . deep sea creatures that few men have ever seen.

An armed diver feeds them several times a day—*by hand!* On a full tummy, even a tiger shark usually relaxes. There's a wary truce on now, as the fish watch this diver "sweep up" their underwater home with a vacuum cleaner of Monel* nickel-copper alloy.

Millions of gallons of ocean water must be circulated through the tanks each day to keep these sea denizens hale and hearty. This warm salt water itself is extremely corrosive. Besides, it contains sand and debris that are hard on metal equipment.

To prevent breakdowns that would endanger the fish — and run maintenance costs skyhigh, too—the Seaquarium relies on Monel alloy for pump shafts and impellers . . . valves and valve trim.

In fact, they depend on Monel alloy wherever they need long, trouble-free service: in railings, ladders and handrails that must withstand salt water, spray and sea air . . . feeding baskets . . . and, of course, for the tank floor vacuum cleaner.

Do you have a metal problem? One where corrosion or some other destructive condition is causing trouble? Then send now for our booklet, *Standard Alloys for Special Problems.* It may suggest a practical answer to a ticklish problem facing you.

*Registered trademark of the International Nickel Company, Inc.

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What's new IN MATERIALS

...AT A GLANCE

A NEW INSULATING MATERIAL, FIBROUS POTASSIUM TITANATE, is promising as an effective heat barrier at temperatures up to 2200 F. It shows no dimensional change after 6 days' aging at 1900 F. The developer says fibrous potassium titanate might also be useful as an electrical and acoustical insulation, a catalyst support, and a reinforcement for plastics. Still under development, the material is available in limited quantities in blocks, mats and loose fibers. (More details next month.)

ROLLED ALLOY STEEL ARMOR PLATES weighing nearly 50,000 lb each are being used on the Navy's newest ships. In making the plates, ingots are forged, kneaded and squeezed under high pressure before rolling. After rolling, the plates are annealed to prevent flaking. The producer says the plates have higher ductility and more toughness than conventionally rolled armor plates.

A HEAT RESISTANT SILICONE ADHESIVE for bonding stainless steel to itself and to other materials is said to withstand long-time exposure at temperatures up to 600 F. The modified silicone-epoxy adhesive has a tensile shear strength of 700 psi after 200 hr in air at 600 F. Research on the adhesive was sponsored by the Air Force.

ELECTROSTATIC SPRAY PAINTING, now a fairly common production process, can be done with a new hand-operated gun. The hand-operated electrostatic gun is said to be considerably faster than an air gun in spray painting rods, tubes and wires. In spraying other items, the gun has a painting rate equivalent to a conventional air spray gun. (More details next month.)

QUARTZ-REINFORCED PLASTICS may greatly improve strength-to-weight ratios and increase the potential payload of space vehicles. Quartz reinforcement was made possible by the recent development of quartz thread. (More details in a forthcoming issue.)

BETTER STRESS RELIEF OF COMPLEX ALUMINUM PARTS has come out of the development of a thermo-mechanical procedure that substantially

reduces internal stresses caused by quenching after heat treatment. Chief value of the method is that it provides complex, fully heat treated aluminum shapes (particularly die forgings) with a low level of internal stress. The method works by superimposing a system of thermal gradients opposite to those which created stresses during quenching.

A COMPOSITE CHROMIUM-NICKEL ELECTROPLATE protects molybdenum metal against oxidation for over 1000 hr at 1800 F and over 300 hr at 2000 F. Bend tests show the electroplate adheres well to the base metal. The plated molybdenum has potential use in turbine blades and similar high temperature parts. (More details in a forthcoming issue.)

FOUR HIGH STRENGTH MILD CARBON STEELS, said to cost up to 35% less than similar steels currently in use, are now available. A new columbium treatment plus a reduction in carbon and manganese content are said to give the steels a combination of good yield strength, weldability and ductility. Potential uses include earthmoving equipment, truck frames, railroad cars and pressure vessels. (More details next month.)

A SPRAYABLE, SOLVENT-FREE EPOXY COATING shows promise as a lining material for storage tanks and process vessels. With properly designed spray equipment, the coating can be applied in a single coat up to 10 mils thick on a vertical surface without sagging. According to the developer, the epoxy coating does not bubble even in very thick films because volatile components are absent. (More details next month.)

ANOTHER EPOXY COATING DEVELOPMENT is a new spray method for applying room-temperature-curing epoxy coatings. A specially designed spray gun mixes resin and hardener an instant before the mixture is atomized and sprayed. When pressure on the trigger is released, a plunger forces the remaining quantity of mixed resin and hardener through the orifice, leaving no material to harden and clog the gun.

A NEW PRECIPITATION HARDENING STEEL is said to have high strength and good corrosion resistance at temperatures up to 1400 F. It also has good yield strength and ductility at temperatures as low as -320 F. The new material is being considered as a replacement for precipitation hardening stainless steels and 5% chromium die steels in aircraft and guided missile structural parts. (More details next month.)

Turn to page 123 for more "What's New in Materials"

MATERIALS BRIEFS

Ant Antics

All the activities of an ant colony can be observed through the transparent walls of a polystyrene ant farm. A clip-on top, removable for introduction of ants, food, water and soil, contains a series of holes for ventilation.

Blood Chilling Device

A specially designed stainless steel heat exchanger provides a safe way to cool and rewarm a patient's blood during heart surgery. Blood is cooled from 98.6 F to 81 F in one pass through the unit.

More Exact Meat Balls

Two identical aluminum die castings operated by scissor-like handles are used for molding firm, uniform meat balls. The device is said to save time, at the same time eliminating messy hand molding.

Movable Plastics Eyes

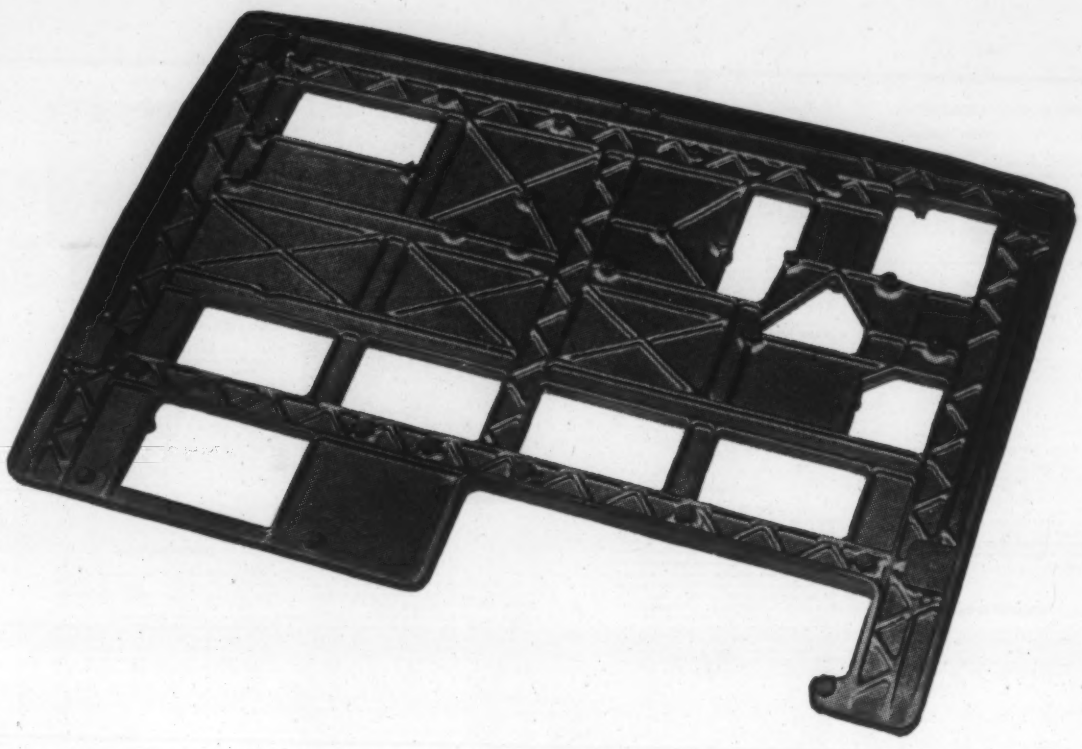
Custom-made plastics eyes that move in the eye cavity like normal eyes are now in use. The eyes are made from a methyl methacrylate resin similar to that used by dentists to construct dentures.

In the Groove

Two small elements of lead zirconate-titanate comprise the heart of a new ceramic stereophonic record-playing cartridge.

Stainless Steel Umbrella

A retractable stainless steel dome, said to be the first such dome ever built, will provide Pittsburgh with an open air stadium that can be converted to a weatherproof auditorium at the press of a button. The stadium will accommodate up to 14,000 people.



DUCTILITY

A CASE IN POINT—This ninety-six pound casting was made for the National Cash Register Co. of Nodulite®, Hamilton Foundry's ductile iron. The casting forms the base for the new Post-Tronic Accounting Machine. It measures 37½" by 23½" with sections varying from ¼" to 1½". Ductile iron was chosen for this part because of its ductility, dimensional stability, rigidity, and machinability.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures used for gray iron. It has high strength: up to 120,000 psi minimum tensile strength in standard grades. It is tough: Charpy impact strengths up to 115 ft.-lbs. in standard grades. It is ductile: elongation is possible up to 25% after short time annealing. And it is wear resistant: spheroidal graphite particles provide for self-lubrication. Hamilton Foundry regularly casts 60-45-10, 80-60-03, 100-70-03, and 120-90-02 grades of ductile iron as well as high alloy Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules —will be met.

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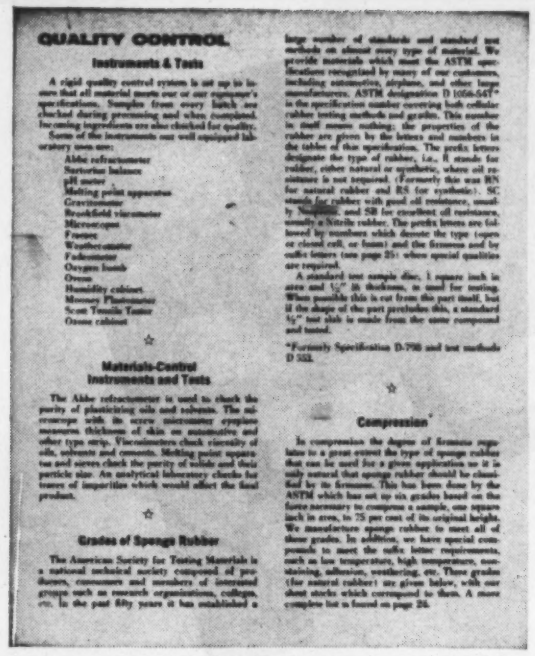


QUALITY CONTROL

Instruments & Tests

A rigid quality control system is set up to insure that all material meets our or our customer's specifications. Samples from every batch are checked during processing and when completed. Incoming ingredients are also checked for quality.

Some of the instruments our well equipped laboratory uses are:

Abbe refractometer
Sartorius balance
pH meter
Melting point apparatus
Gravitometer
Brookfield viscometer
Microscopes
Pycnex
Weather-ometer
Fadeometer
Oxygen bomb
Ozone
Humidity cabinet
Mooney Plastometer
Scott Tensile Tester
Ozone cabinet

☆

Materials-Control Instruments and Tests

The Abbe refractometer is used to check the purity of plasticizing oils and solvents. The microscope with its micro micrometer eyepiece measures thickness of skin on automotive and other type strip. Viscosimeters check viscosity of oils, solvents and cements. Melting point apparatus and sieves check the purity of solids and their particle size. An analytical laboratory checks for traces of impurities which would affect the final product.

☆

Grades of Sponge Rubber

The American Society for Testing Materials is a national technical society composed of producers, consumers and members of interested groups such as research organizations, colleges, etc. In the past fifty years it has established a large number of standards and standard test methods on almost every type of material. We provide materials which meet the ASTM specifications recognized by many of our customers, including automotive, airplane, and other large manufacturers. ASTM designation D 1056-54T* is the specification number covering both cellular rubber testing methods and grades. This number in itself means nothing; the properties of the rubber are given by the letters and numbers in the tables of that specification. The prefix letters designate the type of rubber, i.e., R stands for rubber, either natural or synthetic, where oil resistance is not required. (Formerly this was RS for natural rubber and RS for synthetic). SC stands for rubber with good oil resistance, usually by Neoprene, and SB for excellent oil resistance, usually a Nitrile rubber. The prefix letters are followed by numbers which denote the type (open or closed cell, or foam) and the firmness and by suffix letters (see page 25) where special qualities are required.

A standard test sample disc, 1 square inch in area and ½" in thickness, is used for testing. When possible this is cut from the part itself, but if the shape of the part precludes this, a standard ½" test slab is made from the same compound and tested.

*Formerly Specification D-750 and test methods D 572.

☆

Compression

In compression the degree of firmness regulates to a great extent the type of sponge rubber that can be used for a given application so it is only natural that sponge rubber should be classified by its firmness. This has been done by the ASTM which has set up six grades based on the force necessary to compress a sample, one square inch in area, to 75 per cent of its original height. We manufacture sponge rubber to meet all of these grades. In addition, we have special compounds to meet the softs latter requirements, such as low temperature, high temperature, non-staining, adhesion, weathering, etc. These grades (for natural rubber) are given below, with our closest stocks which correspond to them. A more complete list is found on page 24.

ASTM GRADE NO.	COMPRESSION TO 75% LBS. PER SQ. IN.	OUR STOCK NO.
R 10	½ to 2	1221
R 11	2 - 5	1323
R 12	5 - 9	1525
R 13	9 - 13	1729
R 14	13 - 17	1829
R 15	17 - 24	1983

☆

Graphs showing the complete compression — deflection curves of these stocks are given below.

☆

A sample disc, one square inch in area, is cut from every roll of sheet machine stock we manufacture. This is tested and graded by ASTM standards. Quality control graphs maintained on these tests show the compression, compression-set, aged compression change, density and thickness. These graphs are constantly watched by the Production Department to see that quality is maintained.

For cord and molded goods, standard practice in the industry is to prepare and test a slab of the same compound. This is not always conclusive and therefore not entirely satisfactory. We have developed special tests that can be made on the finished product. Examples of these special test requirements are found on the many molded items we make. Automobile parts, such as weatherstripping, trunk seals and cowl gaskets are tested by applying sufficient force to compress a 12" length ¾", Horn rings, bicycle seats, sponge balls and such are given special tests on the completed part, the type of test depending on the specific property most important for the application.

☆

Compression-Set

Rubber compressed for an extended period of time does not completely regain its original height. This loss in height is called "compression-set." This figure must be kept low or the rubber loses its ability to form a close seal.

We continually have requests from customers for information as to what set the rubber will take in their applications. The conditions of use vary as widely as the immeasurable uses for sponge rubber. To get basic information we have run compression-set tests under different conditions of time and temperature on standard ½" samples. Thinner stocks may have greater sets than those in which the loss due to the thickness of skin in relation to the total thickness. However, the test samples were taken from regular production and are representative of our product.

The standard compression-set test for sponge rubber is to compress the sample to 50 per cent between two steel plates. At the end of the test period, usually 22 hours at 158° F., but also run at room and other temperatures, and for varying periods of time, the sample is removed, allowed to rest for 30 minutes, and measured. The per cent loss in height is the compression-set figure.

In the ASTM method, the compression-set is figured as the per cent of the deflected height lost. This gives a figure just double that of the original height lost and has led to considerable confusion. Therefore, if the compression-set is given as an ASTM figure, just divide by two to get the actual % height loss.

Room Temperature

Our stocks show a remarkably low set at room temperature. After being compressed 50% for 60 hours, the average set of hundreds of samples is around 2-3 per cent. Graph II shows compression-set curves of two of our stocks over an eight year period. At the end of eight years, sets averaged between 30 and 35 per cent. This should be a convincing argument that these stocks could be used as gaskets or in compression for an extended period without losing their sealing properties.

Elevated Temperatures

The standard ASTM compression-set test is for 22 hours at 158° F. By this test, our production stocks, when made into standard ½" ASTM test slabs, will be within the ASTM limits.

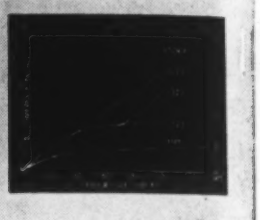
☆

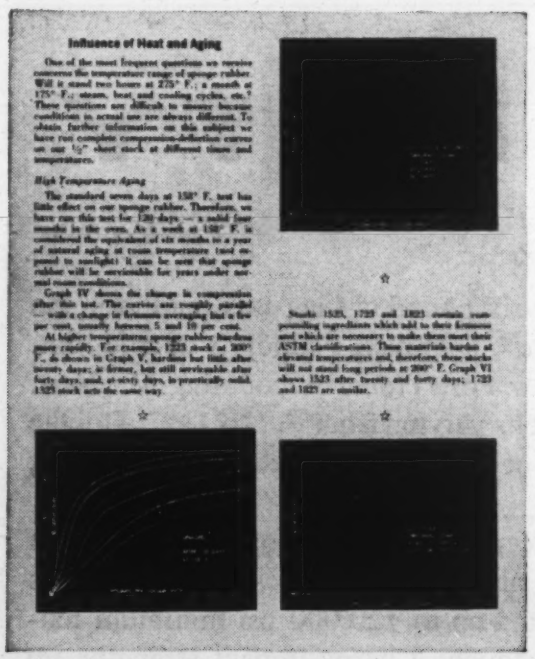
As noted before, thin stocks, due to their fine cores and comparative skin thickness, tend to have higher sets.

At longer times or higher temperatures compression-set increases. Although sponge rubber should not be used in compression at elevated temperatures where loss set is desired (as the rubber has a tendency to cure up in the new compressed position) it is possible to go beyond the test times and temperatures and still have some sealing properties left.

Graph III shows the change in compression set over a period of 1680 hours at 120° F. Our 1101 stock, especially compounded for high temperatures, was kept in compression for 7 days. At the end of this time, the set was under 10 per cent.

At temperatures of 200° F., for 22 hours, all stocks but 1101 have sets of over 60 per cent and at 86 hours regain only a few per cent of their compressed height. However, 1101 has a set of only 20 per cent after 86 hours at 200° F. Therefore, if a material is required which must have a low compression-set at higher than normal temperatures, our 1101 will give excellent results.





Influence of Heat and Aging

One of the most frequent questions we receive concerns the temperature range of sponge rubber. Will it stand two hours at 275° F.; a month at 175° F.; steam, heat, and cooling cycles, etc.? These questions are difficult to answer because conditions in actual use are always different. To obtain further information on this subject we have run complete compression-deflection curves on our ½" sheet stock at different times and temperatures.

High Temperature Aging

The standard seven days at 158° F. test has little effect on our sponge rubber. Therefore, we have run this test for 120 days — a solid year — months in the oven. As a week at 158° F. is considered the equivalent of six months to a year of natural aging at room temperature (not exposed to sunlight) it can be seen that sponge rubber will be serviceable for years under normal room conditions.

Graph IV shows the change in compression after this test. The curves are roughly parallel — with a change in firmness averaging but a few per cent, usually between 5 and 10 per cent.

At higher temperatures sponge rubber hardens more rapidly. For example, 1323 stock at 300° F., as shown in Graph V, hardens but little after twenty days; is firmer, but still serviceable after forty days, and, at sixty days, is practically solid. 1525 stock acts the same way.

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Stocks 1525, 1729 and 1823 contain compounding ingredients which add to their firmness and which are necessary to make them meet their ASTM classifications. These materials harden at elevated temperatures and, therefore, these stocks will not stand long periods at 200° F. Graph VI shows 1525 after twenty and forty days; 1729 and 1823 are similar.

☆

These pages and 18 more are yours for the asking

Other Aging Tests

In addition to the aforementioned aging tests, we use oxygen bomb and air-bomb tests; ozonometer or artificial weathering tests, and natural sun aging tests. The bomb tests are conducted at elevated temperatures at 60 psi air pressure or 300 psi oxygen pressure. Our stocks easily pass ASTM and government specifications for these tests. The weather-ometer is a machine that subjects the rubber to a spray (rain), a stream of air (wind), and carbon arc light (sun). In 100 hours the material is given the equivalent of approximately six months in the open. By these steams and by outdoor exposure tests on our roof and in Florida, we check our products constantly and continually strive to improve their aging qualities.

☆

Finding

A standard ASTM flex test is to compress a piece of sponge rubber 250,000 times to 50 per cent. The loss in height, after one hour of rest, should be less than 10 per cent. We meet this test easily in all stocks, usually having less than 5 per cent loss. Even a half-million flexes results in less than 10 per cent height loss. This is of great importance as it is one of the most valuable properties of sponge rubber. It means, for instance, that in vibration damping, the sponge rubber can be compressed millions of times without structural breakdown.

☆

Tensile and Elongation

As sponge rubber is used in compression, tensile strength is not the important property that it is with mechanical rubber. However, some companies still require a minimum value in their specifications. The tensiles of our crude rubber stocks are extremely good. It is hard to give definite figures because thin stocks, due to higher density, have higher tensiles than thick, lower density stocks. However, 1323 runs from 75-100 psi tensile and 500-600 per cent elongation up to ½" Tensiles and elongations decrease to 30-50 psi and 300-400 for 1" stock. 1525 runs about the same in tensile with lower elongation and 1729 has a higher tensile average with elongation running to 300-400 per cent.

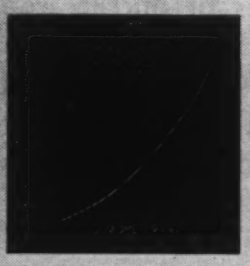
These values run down at the breaking point, i.e., a 75 psi tensile and 500 per cent elongation mean that it would take 75 pounds to break a sample one square inch in cross-section and that the sample would stretch 500 per cent (a one inch length would stretch to six inches) before it breaks. The good tensiles and higher elongations of our sheet stocks mean that the sponge can be stretched considerably without breaking.

☆

Durometer

For many years the Shore Durometer "OO" has been used to check the softness of sponge rubber. Due to its convenience and speed it is still used, although generally replaced by more accurate methods of testing compression. Different people still get different results on the same material, using the Durometer, and thin stocks will have a higher reading than thick ones in tensile). Bearing these facts in mind, we can say that 1323 stock falls in Durometer "OO" range of 25-45. 1325 averages 35-60, and 1725 falls between 45-70.

Many people use Durometer "A", made for mechanical rubber, and often ask how our values compare. Below is a graph comparing the two Durometers.



☆

This conversion graph is not to be considered accurate on all stocks as any surface hardness tester evaluates modulus at low elongation of the reading is taken immediately and modulus at low elongation plus plastic flow if an interval elapses before reading. Thus, not only the pressure used by the operator, but also the time he takes in making the reading, influences the result.

Insulation Value — Heat

The insulation value of a material is the property it possesses of slowing down the transfer of heat. This property can be measured and expressed in a number called the K factor. K factor is defined, in English units, as the amount of heat in B. T. U. (British Thermal Unit) which will flow in one hour through a square foot area 1" in thickness with a temperature gradient of 1° F. A B. T. U. is the amount of heat necessary to raise one pound of water one degree Fahrenheit.

Representative samples of sponge rubber have been tested and found to have a K factor of 0.66. This is higher than most insulating materials and much higher than our Cell-Tite, the non-interconnecting cell structure of which is responsible for a K factor of 0.30 to 0.25.

☆

Insulation Value — Sound

Sound insulation is a complex problem. There is no one value, like the K factor for heat insulation, which tells the whole story. The sound absorption coefficient and sound transmission coefficient are both used in acoustical measurements and of these the former is probably more useful as it can be compared with the published values of many other materials. We have had this sound absorption coefficient measured for our ½" 1233 by the Tube method. In this method a "wall" of sponge rubber is placed at one end of a tube and a sound of definite frequency introduced at the other. The sound waves travel through the tube and hit the rubber where some are absorbed and some are reflected. The reflected waves unite with the original waves and, at certain points where they meet in phase, reinforce them and produce a sound of maximum intensity. Where they meet out-of-phase a minimum sound is heard. These points are determined electronically and by use of a fairly simple formula the sound absorption coefficient is figured.

For our ½" 1223 these values are:

Frequency cycles per second	Sound absorption coefficient
256	0.800
512	0.310
1024	0.945
2048	0.900
4096	0.585

For normal applications acoustical problems, the coefficient of sound absorption at 512 cycles is commonly accepted. Sponge rubber is strongly functionally good at absorbing the higher frequencies.

The average of the sound absorption coefficients for 256, 512, 1024, and 2048 cycles per second is often used as the noise reducing coefficient. In the above case it would be 0.710.

☆

Staining and Tarnishing

There are three general types of staining: Discoloration of the stock itself, i.e., white rubber turning yellow; light blue darkening, etc.; contact stain, and migration stain. The first class does not prove too troublesome as we buy the best colors and compound for maximum color stability. Contact stain as defined by ASTM, occurs when rubber is in close contact with a lacquered or enameled plate under heat. Migration stain occurs when rubber is in contact with the plate under ultra-violet and heat. This is the most important test to us due to the many automotive parts we make.

A standard test for automotive staining originated by Fisher and adopted by ASTM, makes use of a lacquered panel exposed to ultra-violet rays of a sun lamp for a definite time and distance. By this test, some of our crude sheet stocks stain.

When in contact with wood or paper under room conditions, no stain occurs. However, different types of paint and lacquer will react differently and, in case of doubt, the customer should furnish a sample of the material he uses for us to use in making special tests.

Vinyl plastics, due to the stabilizer used, will generally be stained through action of the sulfur in the rubber. Sometimes a fabric backing on the vinyl prevents this.

Metals will usually be tarnished by continued contact with sponge, especially at elevated temperatures. This also is caused by the sulfur in the compound. For special cases we have a sulfur-free compound which will eliminate this trouble. Our 1422S, Sulfur Free Stock, was tested by inserting shiny pennies in slits in the rubber, and kept at 158° F. for 7 days. At the end of this period, there was no tarnishing and the pennies were bright. When tested in standard sulfur bearing sponge, the pennies were badly tarnished.

In addition to this compound, we have 1603, a low sulfur compound, especially made for being covered or in contact with vinyls. Sulfur bearing sponge often stains or discolors vinyl sheeting, especially the light colors. 1603 either eliminates or keeps this discoloration to a minimum.

Fungus Resistance

Natural rubber and the common man-made rubbers which we use are practically free from fungal attack. When growth occurs, it is usually due to foreign matter on the surface of the rubber. It is not necessary to add fungicidal materials to sponge under most conditions.

Vermin Resistance

Like fungus resistance, rubber is to a great extent vermin proof. This is of great importance to our many rug underlay customers. We have had extensive tests made by one of the country's largest laboratories whose conclusions are that it is possible for carpet beetles to reproduce on practically any surface, but on sponge rubber their growth was considerably retarded and larvae were much smaller than normal. Under these conditions, they would normally migrate in search of food.

☆

Resistance to Oils and Chemicals

We have many inquiries as to the effect of various chemicals on sponge rubber. The swelling or shrinkage of sponge rubber is an important property to be considered in many applications. If the sponge swells unduly, it becomes soft and mushy, without strength. The ASTM considers as "medium swell" one that increases less than 60 per cent in volume after 22 hours immersion at 158° F. and a "low swell" stock increases less than 10 per cent.

1101 Stock — for High Temperature Resistance

(Available on special order, minimum requirement necessary.)

Our high temperature stock No. 1101 is an extremely versatile material. Originally designed to give good heat resistance, it also has excellent compression-set and low temperature characteristics. By the standard ASTM method the compression-set runs from a little over five per cent for 22 hours at 122° F. to less than ten per cent for 166 hours. At 200° F. the set is under 12 per cent for 22 hours and 20 per cent for 86 hours. Even under the extremely severe conditions of 72 hours at 225° F. the set averaged between 35 and 40 per cent.

At high temperatures 1101 stock can be used where standard rubber compounds fail. 200° F. – 225° F. have little effect on its softness even after 30 days. At 250° F., twelve days make little change, but at fifteen days the stock begins to harden, and at eighteen days it is very firm.

At 275° F. the limit of continuous use is between three and four days. At five to six days the stock is hard.

For low temperature resistance 1101 stock is surpassed only by 1343 in crude rubber compounds. At −30° there is little hardening and at −67° F. (−55°C.) the change is not great, as is shown by Graph XVII.

Silicone — for extremes of temperature

For uses where continuous temperatures over 350° F. are unavailable, or for extremes of both high and low temperatures, Silicone sponge and Silicone Cell-Tite (a closed cell material) have been developed by our laboratory. Silicone rubber combines the stability of the Silicones with the elastic properties of rubber. It has resistance to aging and retention of chemical and physical properties at temperatures far above and below the limits of rubber.

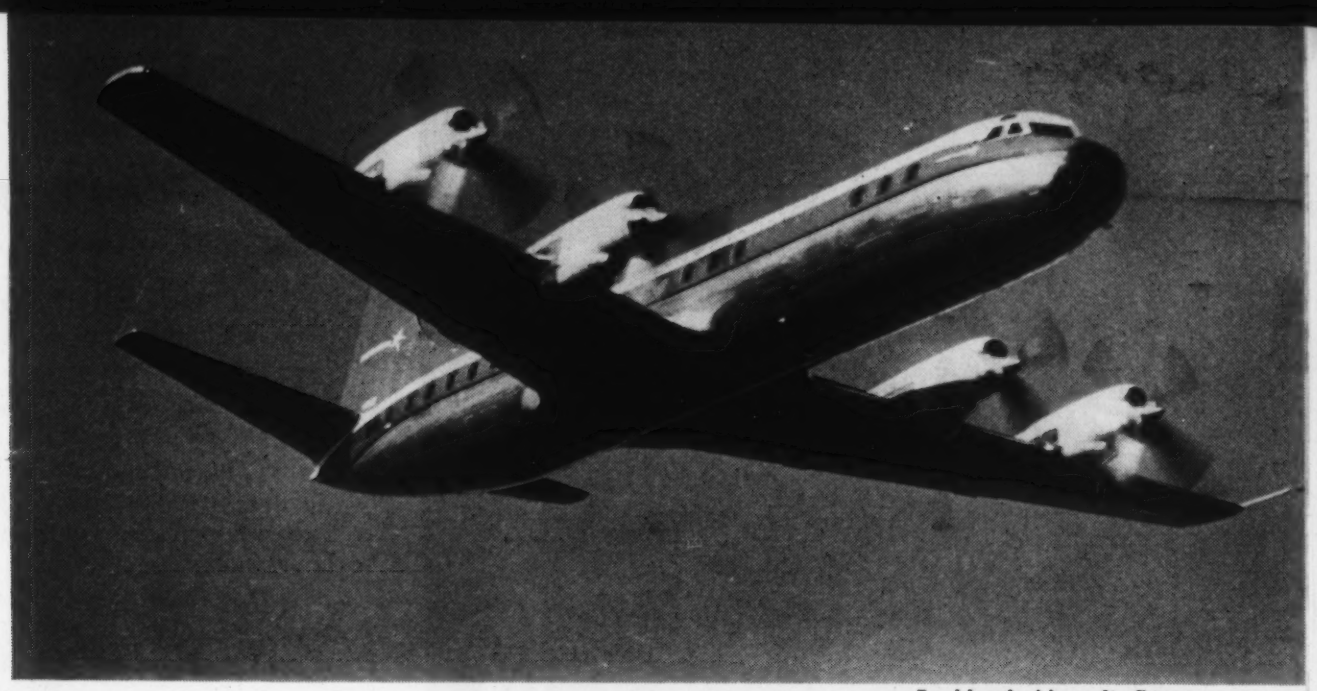
Silicone is several times the price of rubber, but our Silicone Sponges, due to its light weight, is much cheaper than silicone solid rubber.

Silicone Sponges is, to some extent, a custom made product. We can compound this material to meet the customer's requirements, whether it be high tensile, low compression set, extremes of temperatures, etc. Our standard compounds are those which have the best balance of properties, including economy of production, and are considered general purpose stocks. It should be remembered that emphasizing one quality is usually at the expense of another.

For this informative 26-page reference guide on cellular rubber, its properties and uses, write The B. F. Goodrich Company, 421 Derby Place, Shelton, Connecticut

B.F.Goodrich *industrial cellular materials*

For more information, turn to Reader Service Card, circle No. 422



Lockheed Aircraft Corp.

MATERIALS AT WORK

New and interesting applications of engineering materials

B. F. Goodrich Industrial Products Co.

Phenolic-nitrile adhesive bonds aluminum aircraft structures

The Lockheed Electra prop-jet airliner shown in the top photo is said to be the first and fastest of its kind built in America. One of the engineering features that helped to reduce weight and increase strength was the use of a thermosetting phenolic-nitrile rubber adhesive for metal-to-metal bonding of aluminum wing and tail assemblies, internal panels and other structural parts.

According to B. F. Goodrich Industrial Products Co., the bond obtained is "more permanent and durable than that achieved by any other method." As shown in the lower photo, the adhesive is supplied in the form of tape. When applied and cured under heat and pressure (350 F at 100 psi), the adhesive provides a shear strength greater than 4000 psi. In addition, the adhesive, though quite hard, is elastic enough to allow for the uneven expansion that develops between unlike materials.

The huge airliner, designed to carry up to 98 passengers, is 104½ ft long and 32 ft high to tip of tail. It has a 99-ft wing span and a maximum gross take-off weight of 116,000 lb.

Irradiated polyethylene protects "wet" motor

Irradiated polyethylene insulation is the key to the successful development of the new "wet" motor shown in the photo at left.

According to General Electric Co., irradiated polyethylene insulation permits windings, bearings and magnetic components to be completely immersed in water. And although the motor was specifically designed for fresh and salt water immersion at temperatures up to 600 F, it is expected to find use in various chemical streams as a result of irradiated polyethylene's good chemical resistance.

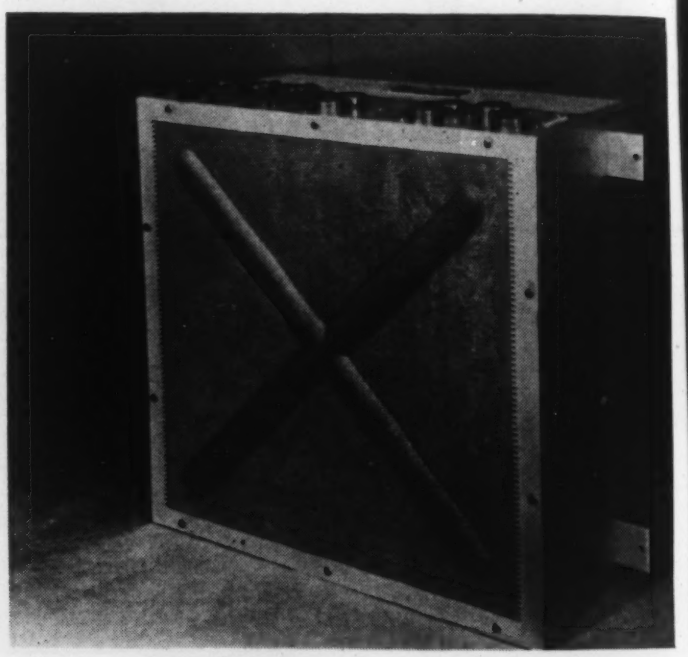
Two major uses presently being considered are: underwater drive motors and integrated pump-motors. The primary advantage offered by the wet motor in pumping applications is the elimination of a pump seal. The water being pumped is allowed to circulate through the motor's internal electrical and mechanical components, thus avoiding the 3000 psi of pressure that a standard pump seal would have to withstand.

Three magnesium parts reduce weight of ICBM

The use of three lightweight magnesium enclosures for the inertial guidance system of the Arma ICBM has resulted in considerable weight reductions and hence decreased fuel requirements. In addition, the magnesium components satisfy all requirements for resistance to thermal shock and vibration.

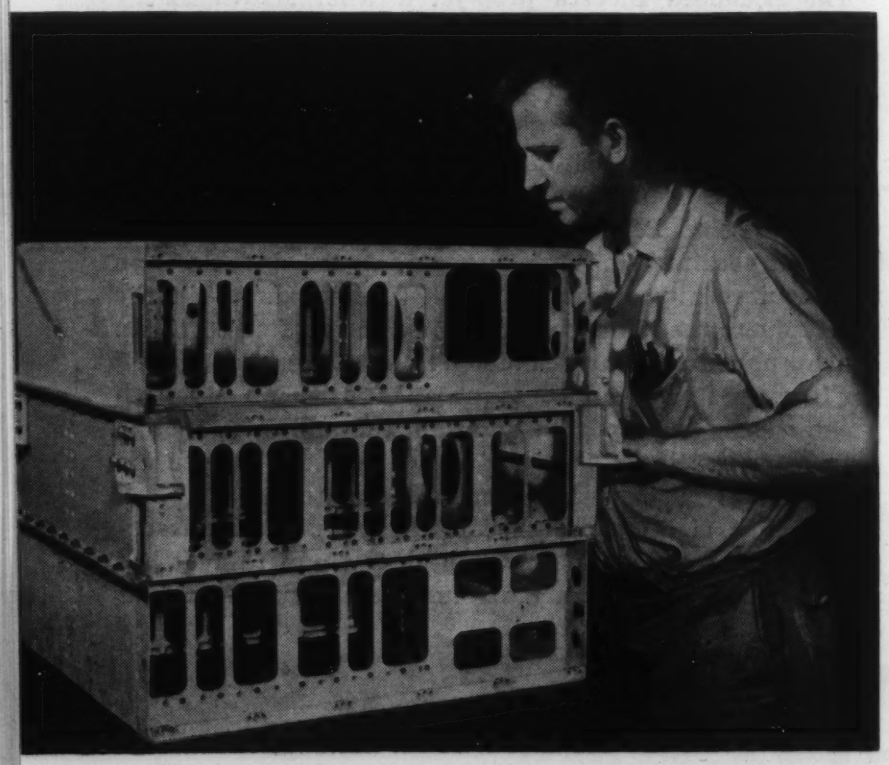
According to Arma Div., American Bosch Arma Corp., two of the enclosures—the three deck computer section and central control cases—are fabricated entirely from magnesium extrusions. The third enclosure—the inertial platform—contains two deep drawn magnesium hemispheres.

Most of the extrusions used are AZ31B alloys. One side extrusion in the central control case, however, is AZ61A. The hemispheres are of AZ31B alloy.

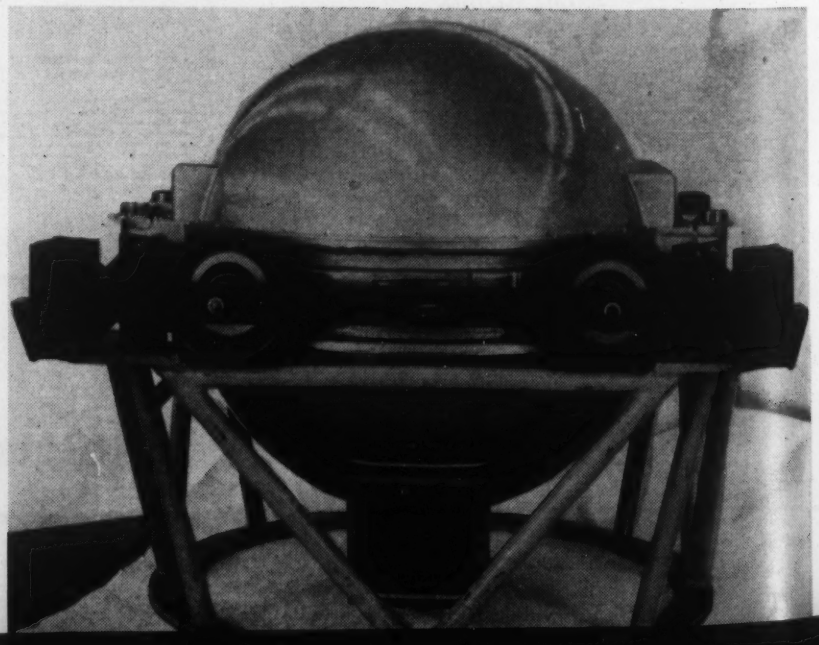


Central control case.

Three deck computer section.



Inertial platform.

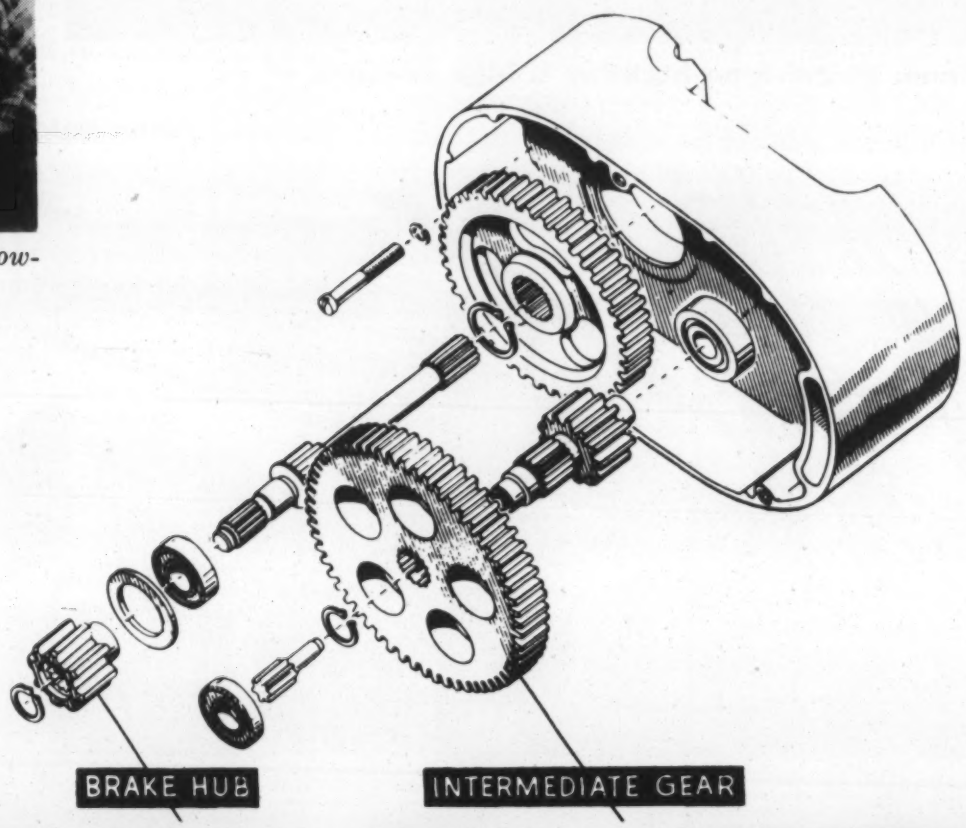


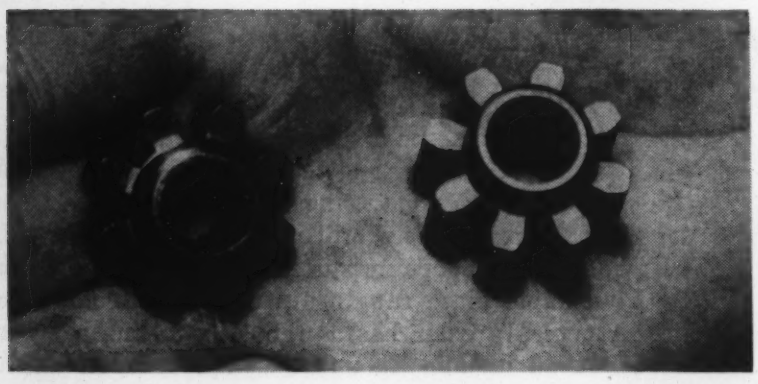
***Chain hoist** utilizes two iron powder parts for vital components.*

MATERIALS AT WORK

Metal powder parts solve design problem

The use of copper-infiltrated iron powder parts has resulted in closer tolerances, better surface finish and improved mechanical properties in key parts used in a chain hoist. According to Chisholm-Moore Hoist Div., Columbus McKinnon Chain Corp., the metal powder parts have solved two major design problems:



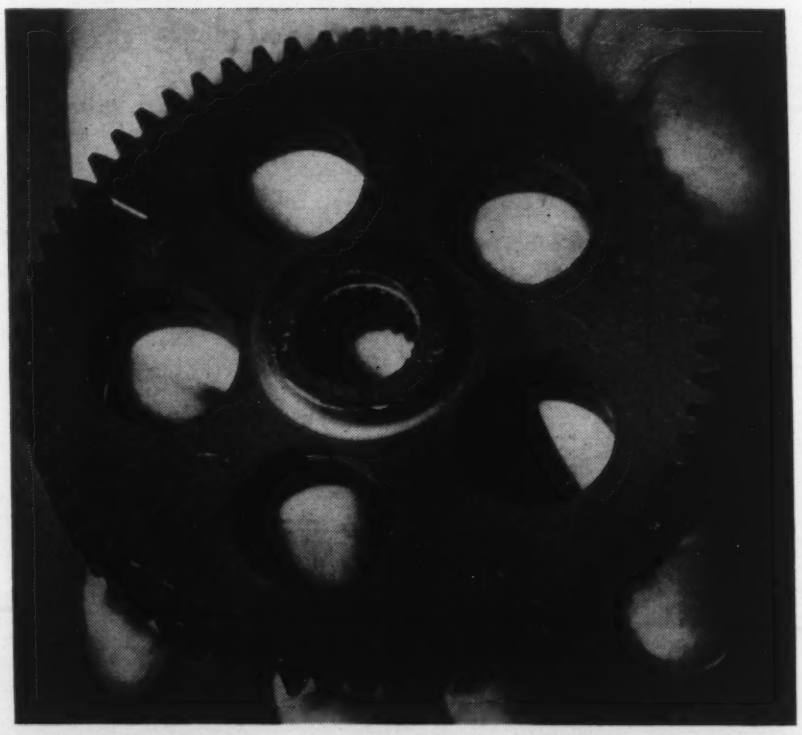


Problem 1: To design a braking system that could bring a full load (up to 500 lb) from a speed of 32 fpm to a full stop.

Solution: A magnetic braking system, a key component of which is a metal powder part "brake hub." As shown in the accompanying sketch, friction disks are splined to the hub which is in turn splined to the drive shaft to form a direct connection to the motor shaft. The brake hub thus allows the friction disks to control the rotation of the drive shaft and consequently the motion of the load.

The brake operates by means of an electromagnet which attracts an armature away from the disks. When the magnet is de-energized, the armature plate is released and spring tension forces the plate against the disks to stop shaft rotation.

The switch from previously used machined bar stock to a metal powder part not only increased efficiency, but reduced cost by 70¢ per part. Properties of the iron powder part are: Rockwell hardness, G60-92; tensile strength, 140,000 psi; compressive strength, 160,000 psi.

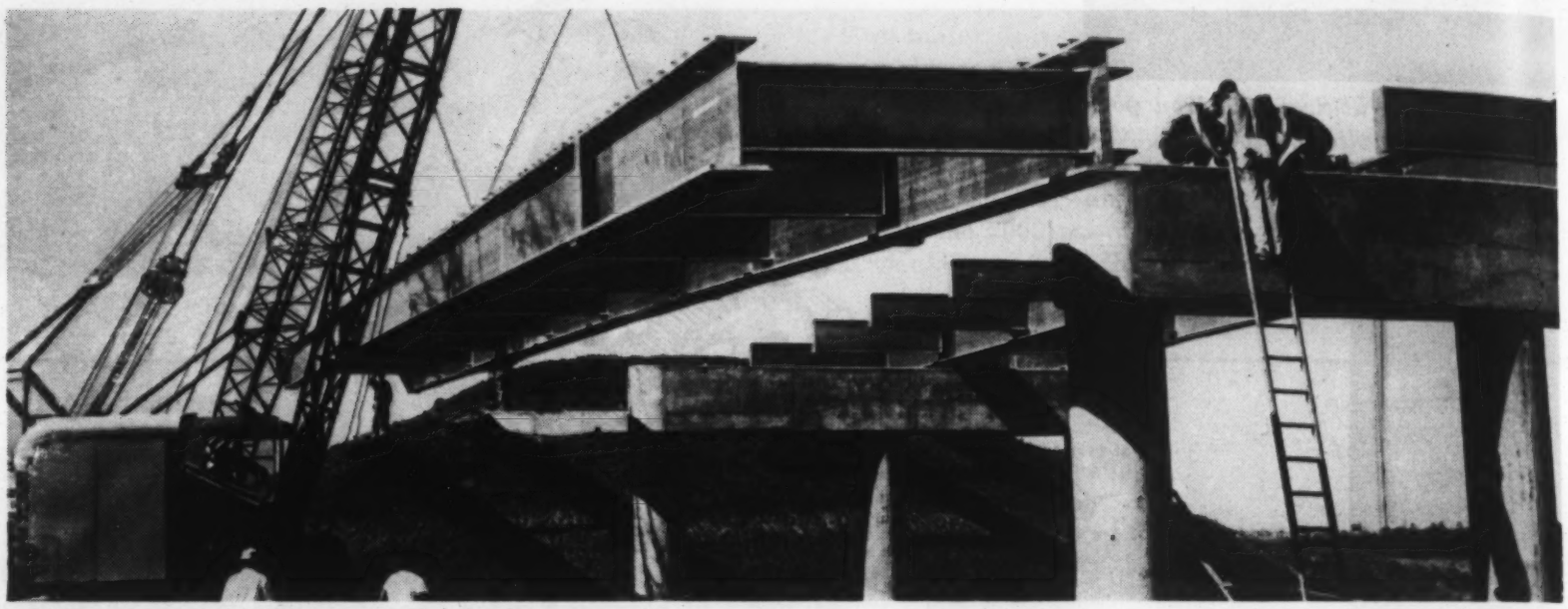


Problem 2: To design a simple but efficient two-reduction gear train which would provide positive lifting of heavy loads.

Solution: The intermediate gear (see photo) is pressed and sintered from an iron powder blend containing 7% copper. Powder metallurgy was chosen for this part because it must have the mechanical strength necessary to transmit power from the motor to the lift wheel smoothly and quietly. In addition, its dimensions must be accurate to within ±0.005 in.

First aluminum girder-type highway bridge consists of . . .

. . . four welded, prefabricated subassemblies.



Two new highway bridge designs use aluminum

The trend toward the use of aluminum in advanced highway bridge design continues to grow (see M/DE, Nov '58, p 12). The two latest bridge designs—one experimental and one already in service—represent two totally different aproaches to the most economical and efficient use of aluminum. The span shown in the top photo is said to be the world's first aluminum girder-type highway bridge. The bridge shown below is said to be the first constructed of aluminum parabolic arches.

Girder bridge

The girder structure, measuring 222 ft long and 30 ft wide, was constructed from four huge welded prefabricated aluminum subassemblies. Each subassembly consists of two 95 to 126-ft longitudinal girders welded to 9½-ft long aluminum connecting diaphragms. The huge sections were simply placed on concrete piers and bolted.

The girder and diaphragm system is fabricated of high strength weldable plate ranging in thickness from ½ to 1¾ in. A typical girder has a web ½ x 36 in., a lower flange 1¼ x 18 in. and an upper flange ¾ x 12 in. A diaphragm has a ½ x 23-in. web and a 1 x 10-in. flange.

(continued on p 158)

Experimental bridge section *under test at New York University.*

MORE MATERIALS AT WORK

Redesigned terminal turns to epoxy..... 158

Wire thread inserts solve design problem..... 162

RCI EPOTUF Epoxy Resin

"An ideal resin for potting applications"

says J. R. McRobert, vice president, Novi Equipment Company

Engine heat, vibration and road shocks present problems that must be met and mastered in auto air conditioning equipment. And the Novi Equipment Company, Novi, Michigan, has found that an RCI EPOTUF epoxy resin plays a vital role in the manufacture of its air conditioners — successfully seals a copper coil component in the steel magnetic compressor clutch — insuring dependable performance.

"The use of EPOTUF allows a very close tolerance with a permanent, rigid seal that prevents copper-steel contact — and the 'shorting out' that would thereby result," explains Mr. McRobert. "EPOTUF is the ideal resin for our purposes, possessing excellent qualities of adhesion with the exact electrical properties we require."

Manufacturers everywhere are finding increased use for Reichhold's versatile epoxy resins. EPOTUF epoxies offer rugged strength, corrosion resistance and superior bonding properties that have proven perfect for a variety of applications.

And when you do business with RCI, you can count on fast, on-time deliveries anywhere in the country. Why not let *us* know *your* epoxy requirements?

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8104-SR

For more information, turn to Reader Service card, circle No. 409

Awards Competition

To the Editor:

I recall that last year you had an Awards Competition for the Best Use of Materials in Product Design. I am interested in the possibility of entering such a competition if it is to be held again this year and would appreciate any information you may have.

WILLIAM P. MURPHY JR., M.D.
President
Medical Development Corp.
Miami 37, Fla.

Many such letters have been received. This year's Competition was first announced in the October issue. The announcement is repeated in full on pp 115-118 of this issue.

Sandwich panels

To the Editor:

Would you please recommend source data or reference material on the subject of sandwich panels, particularly with regard to such core materials as: polystyrene, Styrofoam, asbestos board, honeycombs.

EUGENE I. DEAS
Reynolds Metals Co.
Richmond, Va.

Articles reprinted from M/DE have been forwarded.

Prizes for Your Letters

A check for $10 will be yours if you write a letter that, in the editors' opinion, is the best published in any given issue. Letters may concern M/DE, the field of materials selection and use, or the engineering profession in general.

For example, letters may compliment us, criticize us, or offer suggestions. They may deal with your personal experiences, gripes or controversial ideas in connection with materials problems or professional aspects of engineering.

Send your letters to: Letters to the Editor, MATERIALS IN DESIGN ENGINEERING, 430 Park Ave., New York 22, N. Y. Letters addressed to individual authors or editors will automatically receive consideration.

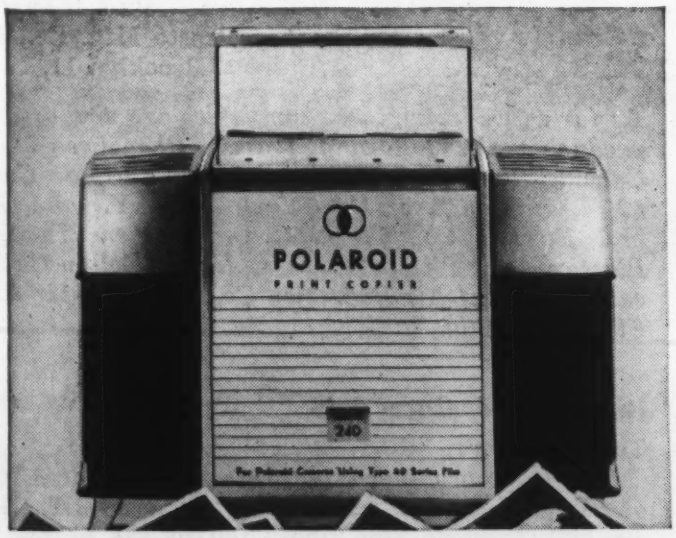
Letters received by the 28th of any month will be considered for the issue dated two months later. Thus, letters received by Dec 28 will be published in February or later. Judgment of the editors is final, and we reserve the right to withhold awards.

CYANAMID

PLASTICS NEWSFRONT

ARGUS SLIDE VIEWER focuses on CYMAC® 400

A number of advantages made CYMAC 400 polymethylstyrene plastic ideal for the smartly designed case of the new Argus PreViewer II color slide viewer. CYMAC 400 resists heat and will not warp when the bulb is lighted for an extended period, or when the viewer is exposed to the hot sun in store windows. It resists stains and may be wiped clean. And it lends itself to attractive design in two tones of blue—color that won't chip off. CYMAC 400 is economically injection-molded for Argus by the Parts Division of Sylvania Electric Products, Inc.



POLAROID PICKS BEETLE® PLASTICS PARTS

Eleven parts, including the handsome pale gray and charcoal case of the new Polaroid Print Copier, are molded of BEETLE urea plastic. Selected for its hard, lustrous finish, durability and range of colors, BEETLE resists staining from oils, greases and common chemicals. Parts are compression-molded by G. M. Laboratories for the Polaroid Corporation. Used in conjunction with the Polaroid Land Camera, the Copier delivers finished prints in 60 seconds.

For the plastic that will best meet the requirements of your particular application, call or write the Cyanamid representative nearest you.

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National Plastics Exposition, Chicago, Nov. 17-21. See us at Booth 540.

For more information, turn to Reader Service card, circle No. 436

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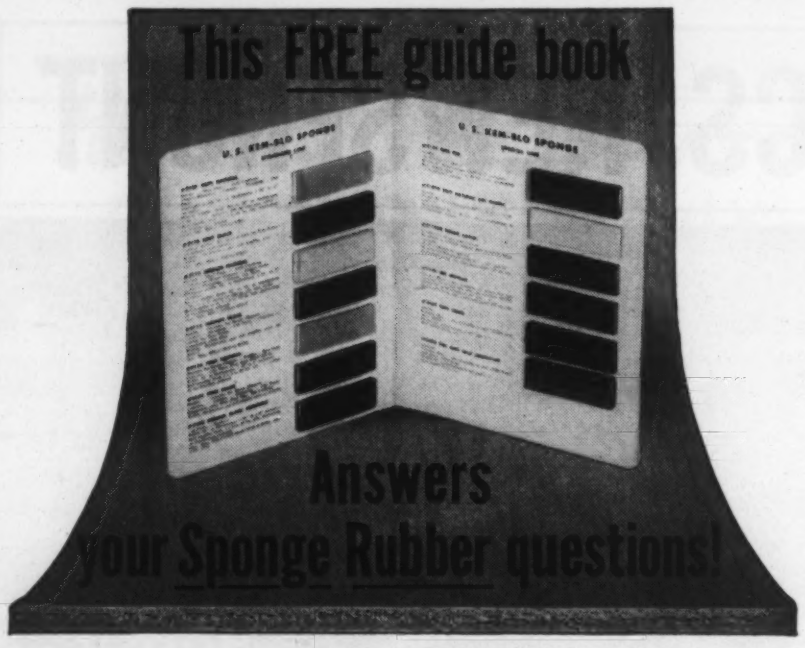

Send today for this file-fitting folder and have 13 different actual Kem-Blo swatches at your finger tips. Kem-Blo is the perfect sponge rubber for your every job. Light... flexible... elastic... can be made to meet your specifications in various widths, compressions, shapes, and thicknesses. Choose from many colors, too! Write U. S. Kem-Blo Department.

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Static-dispersing material

To the Editor:

Your issue of Oct '58, p 3, refers to static-dispersing polystyrene resins. We are extremely interested in static-dispersing material but careful review of the issue failed to disclose further information. Additional data on the resins would be genuinely welcome.

FORREST S. TAYLOR, P.E.
California Industrial Minerals Co.
Friant, Calif.

Additional data are published in this issue, p 148. The resins are produced by Monsanto Chemical Co., Plastics Div., Springfield, Mass.

Foamed plastics

To the Editor:

In reply to a letter printed in your September issue, you mention that you have a list of the names of manufacturers of phenolic and urea foams. To date the various companies mentioned in your article, "How Polyether Foams Compare," Mar '58, have been unable to furnish samples. It seems these foams are still in the talking stage.

We are most interested in obtaining both information and samples on these foams.

PAT HARMON
Presto Mfg. Co., Inc.
Brooklyn 11, N. Y.

As far as we know, these companies are now actively producing the following foams: Phenolics—Union Carbide Plastics Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17, N. Y.; and General Electric Co., Chemical Development Dept., 1 Plastics Ave., Pittsfield, Mass. Urea—Colton Chemical Co., Div. of Air Reduction Co., 1747 Chester Ave., Cleveland, Ohio.

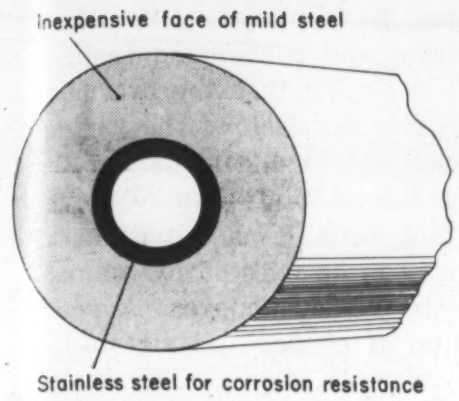
High temperature data

To the Editor:

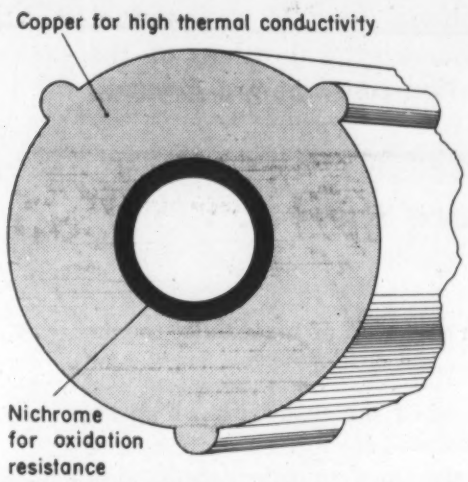
In reference to the item "Meeting Features Data on High Temperatures" appearing in M/DE, Sept '58, p 192, would you kindly tell us the source for obtaining abstracts or papers presented at this meeting.

WILLIAM WOLKOWITZ
Research Engineer
Grumman Aircraft Engineering Corp.
Bethpage, N. Y.

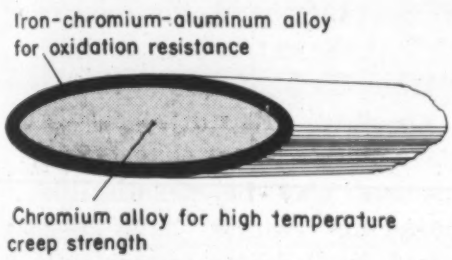
We would suggest writing directly to: Southern California Section, American Institute of Mining, Metallurgical & Petroleum Engineers, 29 W. 39th St., New York 18, N. Y.



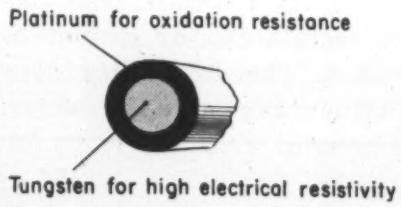
Tubing *for equipment handling corrosive media.*



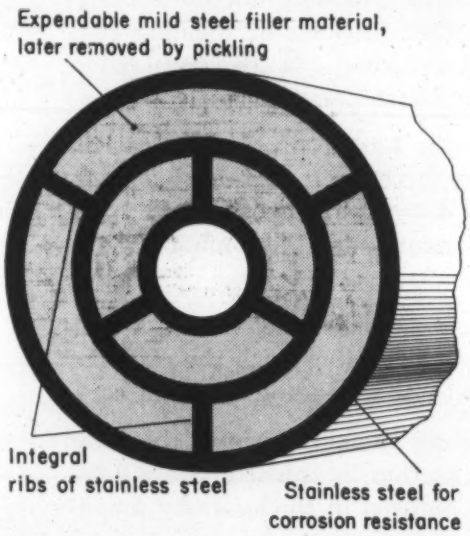
Tubing *combines oxidation resistance with high conductivity.*



Turbine blade *has oxidation resistant coating on creep resistant core.*



Wire *combines high electrical resistivity and oxidation resistance.*



Tube *for heat exchanger made of stainless steel.*

Shapes like these ↑ show how . . .

Coextruded Parts Can Simplify Design

by combining—before fabrication—the physical properties of one material with the desirable surface properties of another.

by **N. R. Gardner,** *Nuclear Metals, Inc.*

■ Coextrusion was developed to meet special service conditions necessitating the use of clad metals. Frequently, the mechanical and physical properties required in the bulk of a given part are quite different from those desired of its surface. The surface material may be selected to protect the underlying bulk from chemical attack or from wear, to achieve certain physical properties such as high emissivity or improved electrical conductivity, or to reduce the cost of the equipment.

A coextrusion is produced by forcing two or more materials through a die at elevated temperatures. The product is a metallurgically bonded composite of two or more materials in a continuous length. Although coextrusions were developed originally for the nuclear energy field, their applications are extending into chemical, high temperature, electrical and electronic equipment.

Materials

The variety of starting materials that can be used is a considerable advantage of coextrusion. The extrusion billet can be built up from forgings, castings, tubular parts, compressed powders or various combinations of these. This high degree of flexibility permits the production of clad parts with many combinations of materials. For example, it is feasible to use not only homogeneous powders, but also to form alloys by combining elemental or compound powders, a procedure that is useful in the fabrication of materials difficult to cast.

However, the nature of the process is such that it establishes certain limitations on the materials that can be coextruded successfully. The materials comprising the composite billet must each be at a temperature at which it will flow plastically under the available pressure. This pressure is empirically determined by actual extrusion experience and is given by the equation:

$$P = K \ln R$$

where K is the extrusion constant

in psi and R is the reduction ratio (the original cross-sectional area of the billet divided by the cross-sectional area of the product).

Some typical values of the extrusion constant are given in the graph. To get relative flow in a uniform and continuous fashion, it is desirable that the extrusion constants for each of the various components in a composite billet differ by not more than 25%.

Thus, suitable combinations of metals can be selected by comparing the various curves. A coextrusion of copper and zirconium, for example, can be produced readily; a combination of aluminum and chromium probably could not be produced.

On the other hand, the requirement that the extrusion constants be within 25% of each other is not absolute. Recent work at Nuclear Metals shows that greater differences may be permissible; encouraging results have been obtained in cladding copper with stainless steel.

At the present stage of development, it is not possible to say positively that a specific combination of metals can or cannot be coextruded. The feasibility of a combination can only be determined by trial.

Shapes

Coextruded shapes in regular production include flats, tubes, ribbed tubes, rods, and elliptical and rectangular cross sections, but many other cross sections can be extruded. Other forms can be produced that do not have a uniform cross section along the length of the extrusion product. These so-called "stepped extrusions" permit an abrupt change in cross section; for example, tubes can have a constant outside diameter and a varying inside diameter or vice versa.

Extrusion forging procedures permit the formation of poppet valves for internal combustion engines or turbine bucket shapes; formation with simultaneous cladding of such parts may be particularly valuable in some cases.

Sizes and tolerances

Coextrusions normally vary between 3 and 20 ft in length. The shortest length is determined by the minimum possible billet length using a typical reduction of area. The maximum length is generally

Coextrusions: here are their . . .

. . . Advantages . . .

In addition to flexibility in design and in selection of materials, coextrusions have the following advantages:

1. Composites formed directly. Because of the ease with which high performance composite structures can be formed it is often more economical to produce metal combinations directly than to fabricate a single component and electroplate, spray or use other processes to obtain the composite.

2. Good metallurgical bond. Coextrusion probably forms a better metallurgical bond than is obtainable by other methods of forming composites because of the high pressures and deformations involved; reduction of area ranging from 5 to 75 times is characteristic.

3. Refractory materials feasible. By the nature of the process, the billet is subjected to compressive and shear forces in a contained fashion. This permits the use of materials that are difficult or impossible to forge, roll or draw, including such materials as powders, metallic compounds and possibly ceramics.

4. Completely sealed products. The coextrusion billet can be assembled to yield a product that is completely sealed, either with the cladding stock or with another alloy that bonds with the cladding and the core.

5. Variable cladding thickness. Cladding thickness is variable over a wide range, from over 50% of the cross section to approximately 0.005 in. Of course, the cladding can be further reduced in thickness by finishing operations such as cold drawing.

6. Excellent mechanical properties. Cladding and core formed by coextrusion have a high density wrought structure with excellent mechanical properties.

. . . and Limitations

Coextrusion has certain limitations, some of which are also applicable to single metal extrusions.

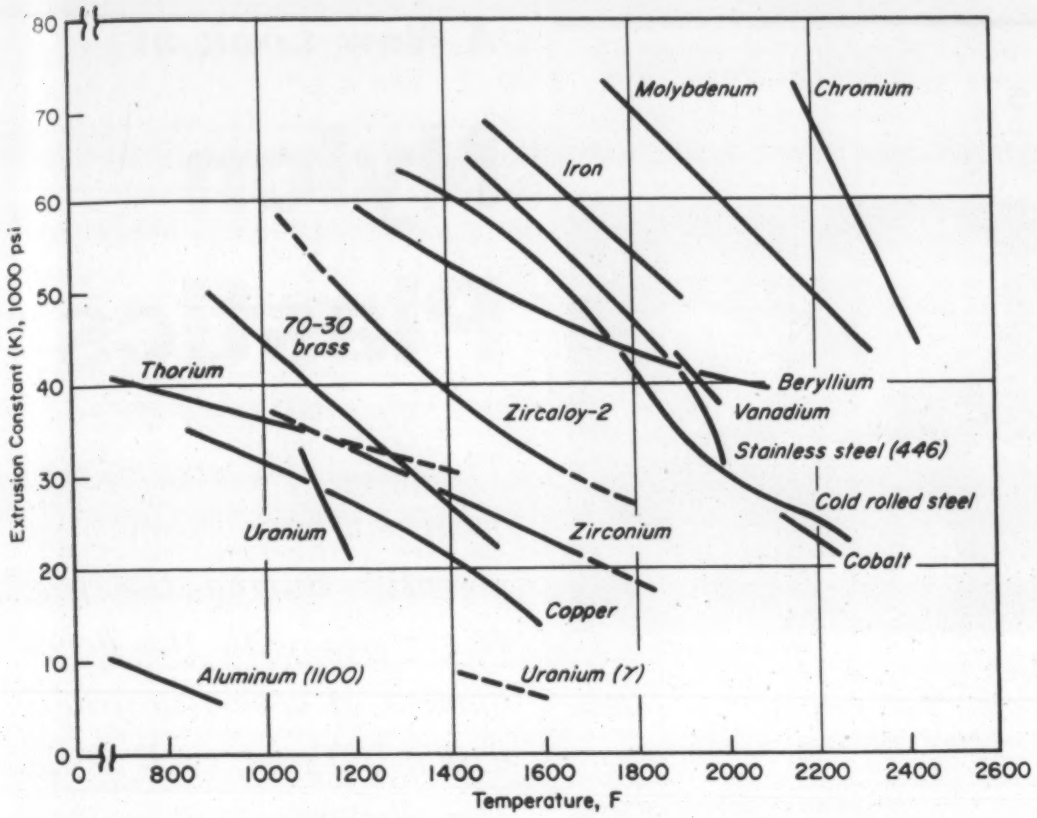
1. Size limited. Billet size and the reduction of area to which it is subjected are limited by the fabricating equipment available. Care must be taken to avoid exposing tools to unduly high stresses and premature failure.

2. Strict control. More careful design and handling of billet components and stricter control of fabrication procedures are required than are usual for single metal extrusions.

3. Material combinations restricted. Selection of the components to be extruded must take into account differences in the coefficient of expansion, the possibility of formation of brittle diffusion compounds at the mating surfaces, and inadequate metallurgical bonding that may result from unclean surfaces or gas contamination in the original billet.

4. Plastic flow required. The materials comprising the composite billet must each be at a temperature high enough to cause them to flow plastically under the available pressure; difficulties may result in attempt to use metals of widely different melting points.

5. Streamline flow required. The metal must flow in streamline fashion to maintain the same area proportion in the extrusion as in the billet and to insure that the billet surface is transformed into the surface of the coextruded part.



Extrusion constant vs temperature.

fixed by the tendency for long billets to cool excessively during the extrusion operation and the tendency of the tools to overheat. Use of relatively soft material, such as aluminum, or larger presses may extend the maximum extruded length to approximately 50 ft.

The cross-sectional area of the extruded part can be of a size that will fit into an 8-in. circumscribed circle. However, parts in production are generally limited to a maximum of 2 in. in dia.

Tolerances are generally ±0.010 in. per in. of the maximum dimension. Tolerances on the wall thickness of tubing are ± 10%.

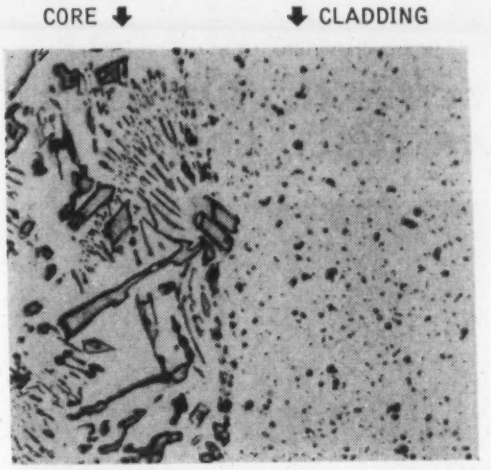
Applications

Coextrusion was originally designed for the fabrication of fuel elements. These composite structures generally have an inner core of fissionable or fertile material, such as uranium, plutonium or thorium, enclosed in a cladding which separates the core from the coolant and reactor environment. Separation is required to prevent direct reaction between the fissionable material and the coolants, to retain fission products and prevent contamination of the reactor system, and to provide a structural member for dimensional and stress requirements. Many reactors now in operation employ fuel elements produced by coextrusion, and the process has come into widespread use in the nuclear field.

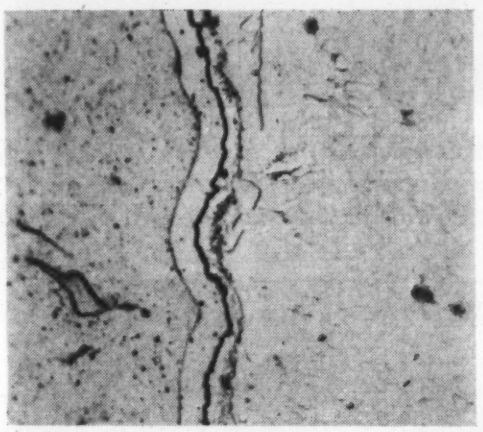
Some typical applications are shown in the sketches. Others include:

1. Coextruded stainless steel-clad molybdenum tubing, used for high temperature structures. The molybdenum and stainless steel serve the separate functions of providing the structure with high temperature strength and good oxidation resistance, respectively. Similar tubing ranging in size up to 1 in., with varying ratios of steel to core, has also been fabricated with columbium in place of molybdenum.

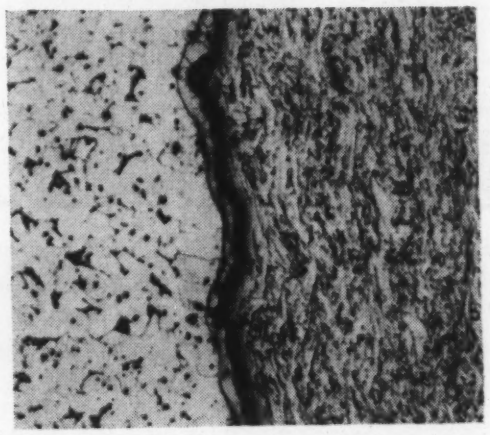
2. Coextruded zirconium or titanium-clad copper tubing, a typical coextruded product providing high thermal conductivity and good resistance to various acid media in a single structure. Such tubing is used in chemical process equipment to achieve high heat transfer rates and maintain long life. An additional example of a heat transfer material is copper tubing clad with stainless steel.



Aluminum-uranium — Aluminum



Uranium — Zirconium



Molybdenum — Stainless steel

***Good bonds** achieved in coextrusion are shown by photomicrographs.*

3. Platinum-clad copper electrodes. The efficiency of electroplating baths is considerably increased by the use of the high conductivity copper core.

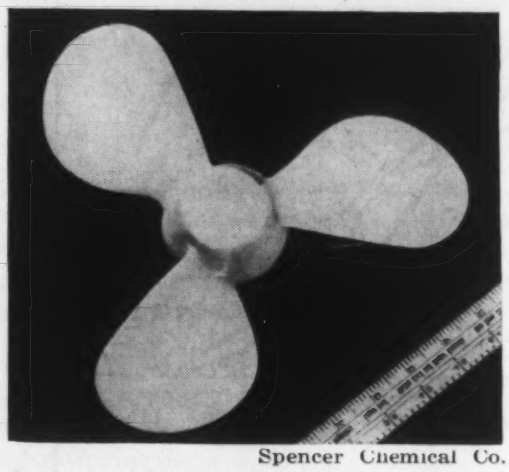
4. Coextruded parts for waveguide and magnetic applications.

Acknowledgments

The processes described in this article were developed at Nuclear Metals, Inc. and its predecessor, the MIT Metallurgical Project, under the direction of Dr. A. R. Kaufmann. Most activities were performed under contract with the U. S. Atomic Energy Commission for the benefit of various government and commercial organizations. The author is indebted to other NMI personnel, J. L. Klein and P. Loewenstein for their technical review, and D. F. Walsh for his editorial assistance.

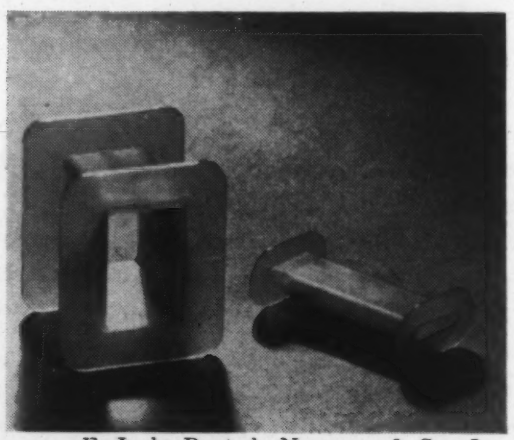
GENERAL PURPOSE TYPES ARE USED FOR . . .

Chicago Molded Products Corp.



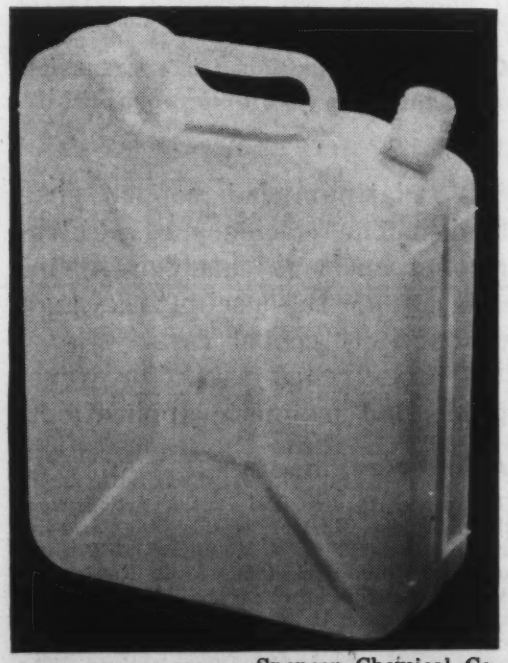
Spencer Chemical Co.

Mechanical parts *which make use of nylon's toughness, abrasion resistance, good frictional properties and heat resistance. Such parts include washing machine pulley slides (left) and boat propellers (right).*



E. I. du Pont de Nemours & Co., Inc.

Electrical insulations *which generally make use of nylon's mechanical durability coupled with its good dielectric characteristics and resistance to heat. Electrical uses include molded parts such as capacitor bases, switch assemblies, alligator clips, pilot lights, sleeves for test prods and control knobs (left), and coil forms (right).*



Spencer Chemical Co.

Chicago Molded Products Corp.

Chemical resistant parts *such as gas cans (left) or handle for paint brush cleaner (right); these also make use of mechanical durability of nylon.*

A New Look at

Nylon Plastics

These durable engineering materials have become more versatile during the past few years with the development of specialty grades and new types, such as the caprolactams.

by Malcolm W. Riley,
Associate Editor,
Materials in Design Engineering

How nylons compare

It is difficult and can be misleading to compare engineering materials too carefully on the basis of static properties alone. However, the values in Table 1 do give an idea of how nylon compares with other materials. The nylons shown are the two most widely used general purpose molding materials. The comparison materials selected are those which could be most competitive with nylon on the basis of properties alone. The cost figures clearly show that nylon is a premium plastic.

Generally, in comparison with the other thermoplastics listed, nylons have high tensile strength and modulus, good impact strength, and high abrasion resistance. As thermoplastics go, they have excellent resistance to heat.

The polycarbonate and acetal plastics are probably the most similar to nylon in all properties shown. Both materials are new (see footnotes *i* and *j*, Table 1). Although a great deal of field

testing has been done, commercial design experience is not as advanced as it is for nylon. Major advantages of the polycarbonate are its high impact strength, heat resistance and low moisture absorption. Present price, of course, is high. The acetal resin is harder and more rigid than nylon; nylon is more resilient and has better abrasion resistance.

Except for these two newer materials, higher density polyethylenes and polypropylene are probably the materials most commercially competitive with nylon —particularly with the lower modulus, type 6 nylon. Polyethylenes and polypropylene are only about one-half as strong as nylon and have lower heat resistance. They are more flexible, having a lower modulus. Their cost—about 43¢ per lb for polyethylenes, 49¢ per lb for polypropylene—is definitely attractive where the premium properties of nylon are not required.

Dielectric properties of nylon are good, but not exceptional. They are quite satisfactory for low frequency insulation applications. In most cases where nylon is used for insulation it is selected because of its resistance to abrasion, heat, and oils and greases in combination with its insulating properties.

Nylons have relatively good chemical stability. They exceed other plastics in resistance to nonpolar solvents, including aromatic and aliphatic hydrocarbons, esters, ketones and essential oils. Nylons absorb and are softened by polar materials such as alcohols, glycols and water. They are dissolved in phenols and formic acid.

TABLE 1—NYLON VS OTHER HIGH IMPACT THERMOPLASTICS

Material →	ASTM ↓	Nylon 6/6[a]	Nylon 6[a]	Polycarbonate	Acetal	Polyethylene Type III[e]	Polypropylene
MECHANICAL PROPERTIES							
Impact Str, ft-lb/in.	D256	0.9-1.3; 2.0	1.0; 2.5-3.0	12-16	1.4	0.3-1.2	1.02
Ult Ten Str, 1000 psi	D638	11.8-13.0; 8.6-11.2	9.5-12.0; 10-11	9-10.5	10.0	2.5-5.0	5.0
Yld Str, 1000 psi	D638	11.8-13.0; 8.5-9.0	8.5-12.0; 5.7-7.0	8-9	10.0	2.5-5.0	4.97
Elong, %	D638	30-90; 200-300	50-200; 300	60-100	15	40-700	>220
Flex Str, 1000 psi	D790	No fracture	No fracture	11-13	14	No fracture	8
Flex Modulus, 1000 psi	D790	410; 175	330-390	375	410	90-150	170
Tabor Abrasion (CS-17 wheel, 1000 gm), mg/1000 cycles	D1044	3-5; 6-8	5.0	24	20	—	—
Rockwell Hardness	D785	R118, M79; R108, M59	R112-118	M70, R118	M94; R120	R30-R50	R93
Def under Load (122 F, 2000 psi),%	D621	1.4	1.7	0.3[j]	0.5	8-16[f]	2.0
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.14	1.14	1.2	1.43	0.941-0.965	0.90
Melting Point, F	D789	480-500	410-420	514[h]	347[h]	250-260[g]	330[h]
Heat Distortion Point, F							
66 Psi	D648	360-390	340-350	283-293	338	140-180	221
264 Psi	D648	150-170	145-150	280-290	212	113	—
Mold Shrinkage, in./in.		0.015	0.010	0.005-0.007	—	0.020-0.050	0.015-0.020
Coef of Ther Exp, °F	D696	5.5×10^{-5}[b]	$4.8\text{-}5.3 \times 10^{-5}$[b]	3.9×10^{-5}	4.5×10^{-5}	9×10^{-5}	6.2×10^{-5}
Ther Cond, Btu/hr/sq ft/°F/in.		1.7[c]	1.19-1.33[c]	1.3	—	2[c]	0.95
Water Absorption (24 hr), %	D570	1.5	1.6-2.3	0.35	0.4	<0.02	0.03
ELECTRICAL PROPERTIES							
Dielec Str (short-time), v/mil	D149	385	440	400	500	480	769-820
Dielec Const							
60 Cps	D150	4.0; 7.6	5.3-6.1	3.17	3.7	2.3	—
10^3 Cps	D150	3.9; 6.4	4.8	—	3.7	2.3	—
10^6 Cps	D150	3.6; 3.6	3.5	2.96	—	2.3	2.0-2.1
Vol Res, ohm-cm	D257	4.5×10^{13}	7.9×10^{14}	2.1×10^{16}	6×10^{14}	$>10^{15}$	$>10^{16}$
Dissip Factor							
60 Cps	D150	0.014	—	—	0.004	<0.0005	—
10^3 Cps	D150	0.02	—	—	0.004	<0.0005	—
10^6 Cps	D150	0.04	—	—	—	<0.0005	0.0002-0.0003
COST, $/lb[d]		1.18		2.50[i]	0.95[j]	0.43	0.49

[a]Values are for < 0.3% moisture (dry as-molded). Where two sets of values are given separated by a semicolon, values after semicolon are for equilibrium moisture content in air (2.5% for 6/6; 2.7% for 6).
[b]Values are approximate and vary with temperature and moisture content.
[c]Cenco Finch.
[d]Approximate price in large quantities, as of October '58.
[e]Higher density type, 0.941-0.965 gm/cu cm; property ranges indicate values obtainable at different melt indexes within this density range.
[f]At 73 F.
[g]Softening point.
[h]Crystalline melting point.
[i]Introductory price for GE's Lexan, presently available in semi-commercial quantities. Commercial price expected to be in range of $1.00-$1.50.
[j]Introductory price for Du Pont's Delrin; commercially available in mid-'59.

General purpose molding and extrusion grades

Type 6/6 nylon (hexamethylene-diamine-adipic acid) is the most widely used general purpose nylon molding material. The newer type 6 nylon (polycaprolactam) is similar in many ways to type 6/6 and there will undoubtedly be a degree of overlap in industrial applications. There do seem to be distinct differences which indicate that each material will ultimately find its own area of use, but it is still too soon to say how important some of these differences are. Claims by materials producers still conflict in some cases.

In comparing general purpose molding grades, type 6/6 is a somewhat harder, more rigid material with a higher service temperature limit and better creep resistance than type 6. Type 6/6 molding compounds have a low melt viscosity, which permits rapid molding cycles but requires experienced molding and limits extrudability. Higher melt viscosity extrusion grades are available.

Special grades of 6/6 include: 1) heat-stabilized grades for molded electrical parts, 2) hydrolysis-stabilized grades for parts to be used in contact with water, 3) light-stabilized grades for weather resistant moldings, 4) higher melt viscosity grades for molding of heavy sections, and better extrudability.

In general, type 6 has more resilience and a somewhat higher impact strength than 6/6, as measured by standard Izod or tensile impact tests. Its lower melting point, providing a greater processing temperature range, is helpful in attaining void-free moldings. Slower solidification in the mold may cause somewhat longer cycles.

In comparison with type 6/6 general purpose molding grades, type 6 has a somewhat higher melt viscosity, which makes it more suitable for molding heavy sections and for extruding shapes, sheet and film.

Special grades of type 6 include: 1) grades with higher flexibility and impact strength, 2) heat and light-stabilized grades for outdoor weathering, 3) grades incorporating nucleating agents to promote consistent crystallinity throughout sections, 4) higher viscosity grades for extrusion of rod, film, pipe, large shapes and blown bottles.

Properties

As can be seen in Table 1, the properties of both nylon 6 and 6/6 are quite sensitive to moisture. The values given for <0.3 wt % moisture content are for dry, as-molded samples. Type 6 absorbs moisture more rapidly than 6/6 and reaches equilibrium at about 2.7% moisture content in 50% RH air and 9 to 10% in water. Type 6/6 reaches equilibrium at about 2.5% in 50% RH air and 8.5 to 9% in water. In designing with nylons, the effect of moisture content on both properties and dimensions must be carefully considered. These effects are summarized in four graphs on p 96. Details are available from materials suppliers.

In addition to the properties shown in Table 1, nylons have extremely good frictional characteristics. Coefficient of friction of unlubricated nylon on steel is about 0.20, depending on loads and speeds. With a lubricant, the coefficient is about 0.15. Normally a lubricant is required only in cases where a heavy load is combined with high speed. When lubrication is required any conventional oil or grease, or even water, can be used. (For detailed information on frictional properties of nylon, see "Teflon and Nylon Bearing Materials," MATERIALS & METHODS, Mar '56, p 100.)

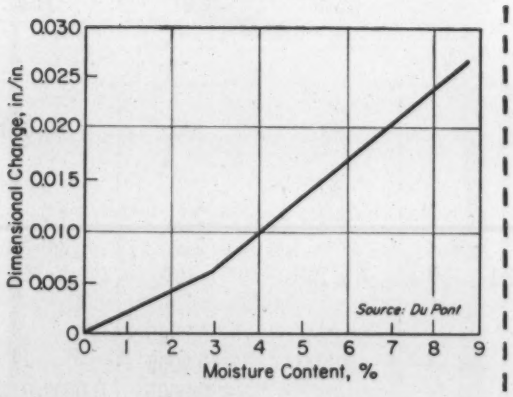
Type 6/10 nylon (hexamethylene-diamine-sebacic acid) is similar to type 6/6, but has lower moisture absorption (resulting in less dimensional change on exposure to moisture), lower heat resistance, lower yield strength and greater flexibility. Heat and light-stabilized grades are available for wire jacketing.

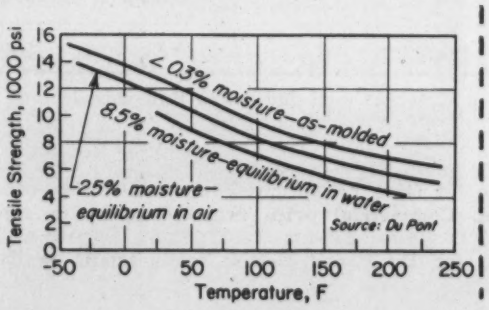
Applications

Uses for general purpose nylons are relatively well-known, mechanical durability probably accounting for the bulk of them. Durability is the primary reason for nylon's use in applications such as gears, valve seats, pulleys, rollers and propellers. Durability combined with good dielectric characteristics is the primary cause for nylon's use in wire jacketing (low voltage wires, coaxial cables and transmission lines),

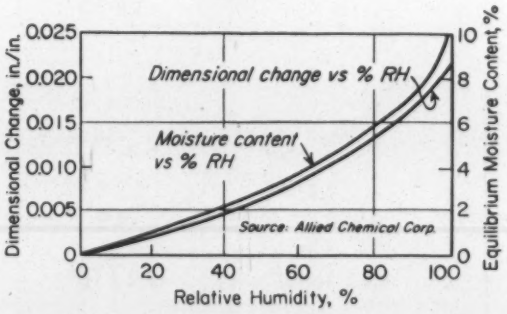
EFFECTS OF MOISTURE AND TEMPERATURE ON . . .

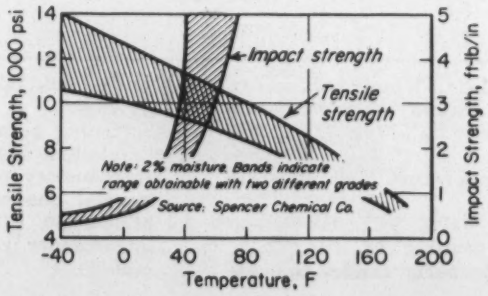
Type 6/6





Type 6





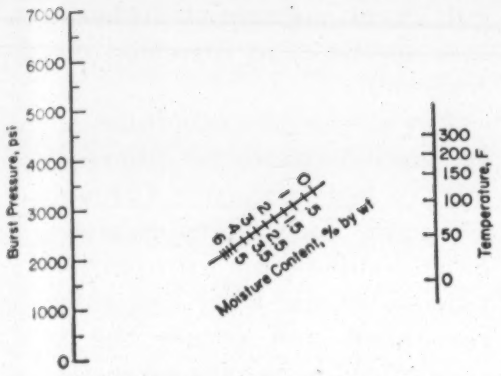


***Fig 1**—Nomograph for determining short time burst strength of one type of high pressure nylon tubing (Nylaflow Type H) at various temperatures and humidities. (Polymer Corp.)*

and in coil forms and test prods. The applications pictured on p 94 are typical of the many uses for nylon. Some of the newer applications include the following:

1. High pressure tubing—Flexible tubing with burst ratings of 2500 to 3000 psi is produced. The high pressure flexible tubing, in addition to high burst strength, has a small minimum bend radius, high resistance to flex fatigue, and relatively wide service temperature range. The nomograph in Fig 1 shows typical short-time burst pressure of one type of tubing at various temperatures and moisture contents.

2. Nylon sheet and film—The availability of nylon sheet and film has recently been announced. Nylon sheet and film are so new that applications have not been fully developed. Extruded in type 6 nylon, they can be vacuum formed, though the processing must be controlled quite carefully. Primary uses at present seem to be in packaging. However, laminates of monoaxial oriented nylon sheet and leather are being used in drive belts.

3. Fluidized bed coating—Use of a patented "fluidized bed" technique provides comparatively heavy coatings of nylon on metals, ceramics and other materials. A bed of dry powder is "fluidized" by means of an ascending current of gas or air within a specially designed tank. The part to be coated is preheated and dipped into the fluidized bed. The heated part melts the powders which fuse to form a uniform, smooth coating.

Specialty grades

A number of specialty nylons have been developed for specific end uses. Among these are filled nylons for wear and abrasion applications, reinforced nylons for applications where high impact resistance and strength are critical, sintered nylons for maximum dimensional stability and wear resistance, and a variety of alcohol-soluble types for coatings and treatments. (Type II nylon [Rilsan], little used in this country, is not covered here. Its major advantage is greatly reduced moisture absorption.)

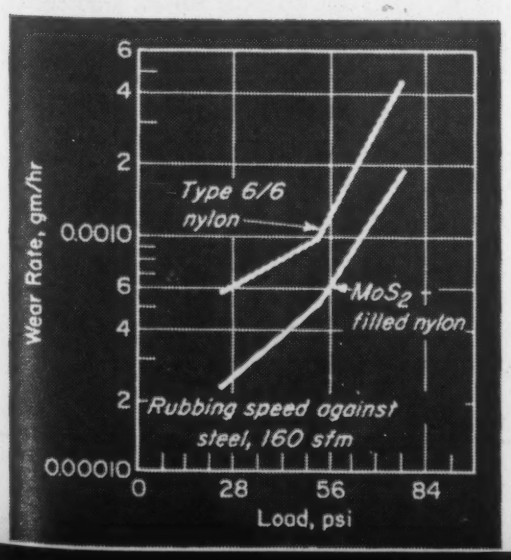
Filled nylon

Molybdenum disulfide, a solid lubricant, is used as a filler for types 6/6, 6 or 6/10, primarily to improve wear, abrasion resistance and frictional characteristics. Flexural strength, modulus and heat resistance are also improved. Properties of a typical filled composition for injection molding are shown in Table 2. The improvement in wear resistance is indicated by the curves in Fig 2 comparing a filled composition with an unfilled type 6/6 material. As a dry bearing material, filled nylon can generally be used at 50% higher PV ratings than unfilled nylon 6/6. An additional benefit is the reduced coefficient of thermal expansion; the coefficient of filled materials is about one-half that of unfilled 6/6 materials, providing better dimensional control and more accurate molding tolerances.

Primary uses for such materials are in bearing or sliding parts such as aircraft fuel pump bearings, oven door slides, sleeve bushings, wear pads and thrust washers. The improved heat resistance also offers some advantages in certain electrical insulating applications.

In addition to molybdenum disulfide, graphite, aluminum stearate and other fillers are used in specialized applications.

***Fig 2**—Lower wear rate of molybdenum disulfide-filled nylon (Nylatron GS) compared with unfilled nylon is shown in these results of accelerated tests of unlubricated bearings. (Polymer Corp.)*



Glass-reinforced nylon

Nylon injection molding compounds filled with chopped glass roving provide substantial increases in tensile strength, heat distortion temperature and, in some cases, impact strength. Typical properties obtainable are given in Table 2.

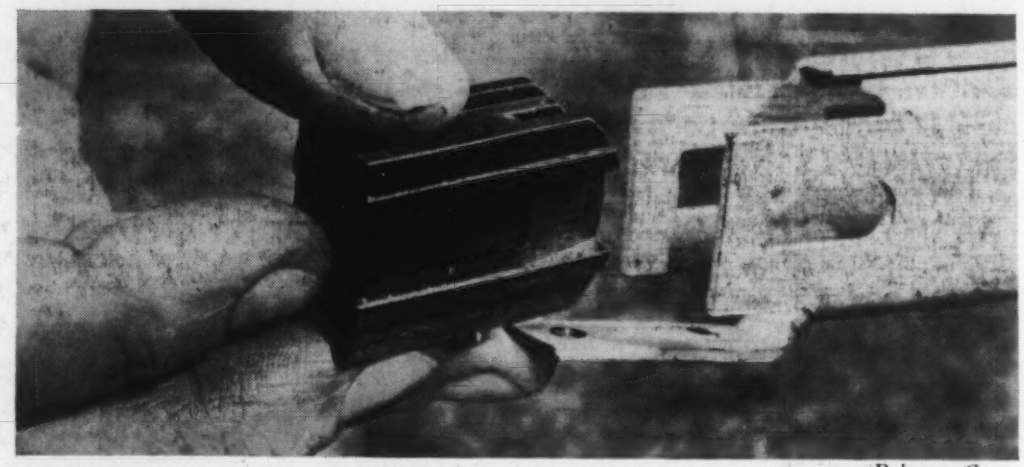
Reinforced compositions are used in a variety of applications where maximum strength and heat resistance are required. Among these are: shuttle bobbins or quills for looms; pulleys for V-belt drives on fractional horsepower motors; and a variety of components for appliances, housings and surgical equipment.

Sintered nylon

Nylon powders precipitated from solution can be pressed and sintered by a process somewhat similar to powder metallurgy. Precipitation from a high temperature solution produces powders of high crystallinity (approximately 80%), and the resulting parts have improved frictional and wear characteristics, as well as higher compressive strength. Tensile strength, elongation and impact strength are reduced, as shown in Table 2. Table 3 compares sintered nylon with injection molded type 6/6, based on wear and frictional data from an accelerated test.

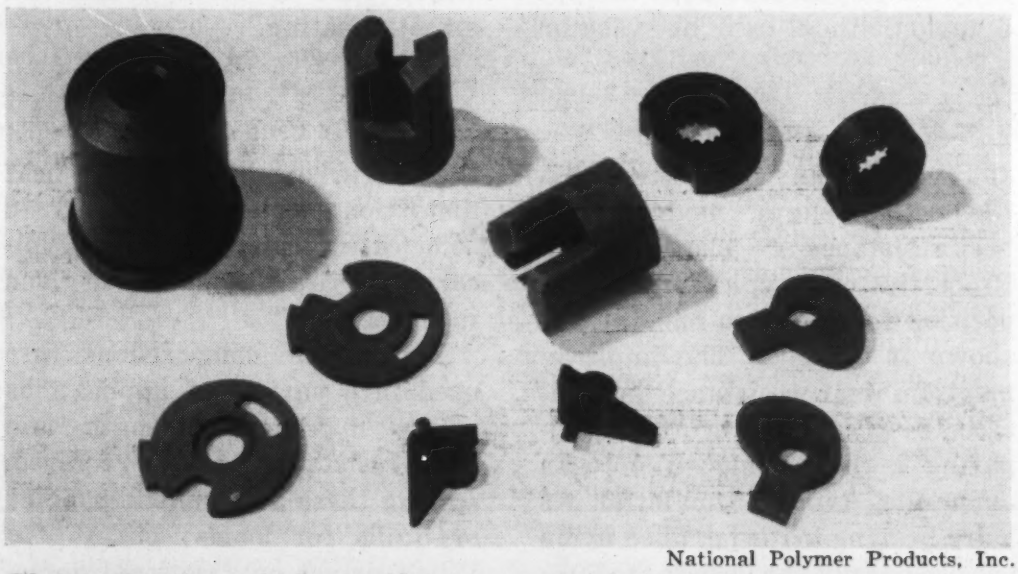
Sintered nylon is not as tough as injection molded nylon; however, where lubrication is diffi-

SPECIAL TYPES INCLUDE . . .



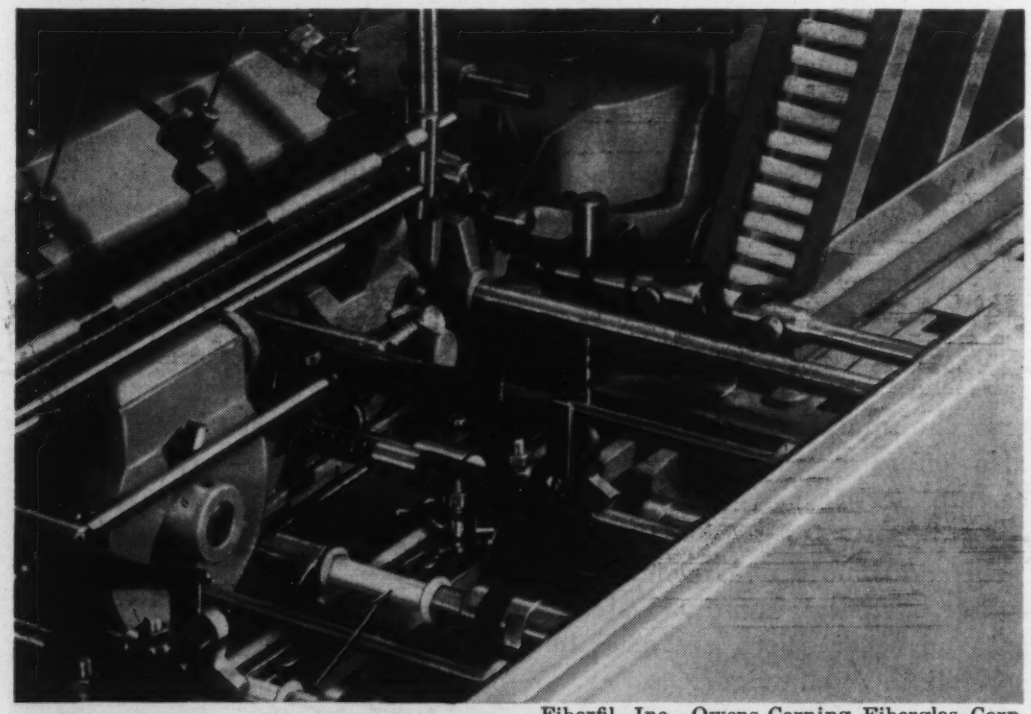
Polymer Corp.

MoS_2-filled nylon *which provides heat and abrasion resistance and dimensional stability superior to that of unfilled nylon for this oven door slide lockstop.*



National Polymer Products, Inc.

Sintered nylon *which provides improved friction and wear characteristics for such parts as cams, gears and bearings.*



Fiberfil, Inc., Owens-Corning Fiberglas Corp.

Glass-reinforced nylon *which provides improved strength and impact resistance for such uses as shuttle bobbins in narrow fabric Jacquard looms.*

cult it can operate at higher loads and speeds than injection molded material.

Use of powder techniques makes it possible to blend fillers thoroughly and uniformly throughout the part. Such fillers as molybdenum disulfide and graphite provide additional wear and abrasion resistance, and reduce the tendency of nylon to take up moisture.

At present, sintered nylon is used in cams, slides, rollers, bearings and other parts subject to wear in business machines, automotive equipment, aircraft instruments and textile machinery.

Soluble nylon

Two major types of alcohol-soluble nylons are available: type 8 (alkoxy-substituted nylon), and two grades (composition undisclosed, possibly copolymers) produced by Du Pont. Soluble nylons are primarily intended for coatings, adhesives and molded high impact parts.

Type 8—Produced under a Du Pont license by Belding Corticelli, type 8 materials are pliable, having elastomeric properties. Although thermoplastic, they can be crosslinked with catalyst and heat where improved heat stability and chemical resistance are required. Properties of both uncured thermoplastic and crosslinked materials in film form are shown in Table 2.

Although type 8 nylons can be injection molded or extruded, their largest use is as protective coatings or adhesives. The materials are soluble in phenol and the lower alcohols. They are insoluble in most other solvents, except in the presence of substantial quantities of these prime solvents.

Crosslinking to form a thermoset is carried out by including an organic acid in the resin solution and heating to an elevated temperature. Crosslinking increases resistance to solvents and boiling water; increases tensile strength and toughness; decreases elongation, flexibility and moisture absorption; and provides substantial increase in high temperature resistance.

Preformed parts can be case-

TABLE 2—SPECIAL TYPES OF NYLON

Type → / ASTM ↓	MoS_2-Filled Type 6/6[a]	Chopped Glass-Reinforced[b]	Sintered[f]		Alcohol-Soluble Nylons		
			Unfilled	MoS_2-Filled	Type 8 Uncured	Type 8 Crosslinked	Other Types[l]
Ten Str, 1000 psi D638	10-13	14.0-18.5	3.5-5.4[g]	2.9-5.3[g]	2.6-4.0	6.2-6.5	11.8-13.0
Elong, % D648	—	1.6-1.7[e]	Nil	Nil	500-800	350-450	300[e]
Compr Str, 1000 psi D695	—	15-16	15.7-20.8	11.5-19.8	—	—	—
Flex Str, 1000 psi D790	13.5-15.0	21-22	6.4-7.2	4.6-9.9	—	—	[m]
Def under Load (2000 psi, 122 F), % D621	—	0.38-0.48[d]	0.37-1.04	0.97-1.0	—	—	20
Izod Impact Strength, ft-lb/in. D256	0.62	2.0	0.5-0.9[h]	0.9[h]	—	—	>16
Hardness	—	M90-100[e]	D80[i]	D79[i]	—	—	R45-83[e]
Specific Gravity D797	1.16-1.17	1.33	1.11	1.19-1.21	1.09	—	1.08
Water Absorption, % D570	1.5	0.26-1.2	—	—	5.5-10.5	1.2	2.0
Heat Dist Point (264 psi), F D648	347	410-490	—	—	[k]	[k]	—
Dielec Str (short-time), v/mil D149	356	—	370-380	448-480	—	—	420
Coef of Ther Exp, per °F D696	3.2×10^{-5}	$2.9\text{-}3.8 \times 10^{-5}$	—	—	—	—	8.2×10^{-5}

[a]Material: Nylatron GS, injection molding compound produced by National Polymer Products, Inc.
[b]Range of properties obtainable in grades G-1, G-2, G-3 (types 6/6, 6/10 and 6) in Fiberfil Nylon-G, molding compound produced by Fiberfil, Inc.
[c]ASTM D638.
[d]At 4000 lb, 122 F.
[e]Rockwell.
[f]Ranges of typical properties of Nylasint sintered parts produced by Polymer Corp.
[g]ASTM D648.
[h]Special test: Bushing ½ in. i.d., ¾ in. o.d., ¾ in. long placed on its side, centered between a rigid bottom plate and sliding top plate. Steel balls of increasing size are dropped from height of 1 ft until bushing breaks.
[i]Durometer.
[j]Ranges are typical for BCI 808, 809, 818, 819 and 829 uncured film; and for 818 crosslinked film. Resins produced by Belding Corticelli Industries, Inc. ASTM test methods undesignated.
[k]Melting range 320-385 F for uncured; over 575 F for crosslinked.
[l]Ranges given as typical for Zytel 63 and 69 at 0.2% (dry) moisture content.
[m]Flexural modulus is 30,000 psi.

TABLE 3—BEARING PROPERTIES: SINTERED VS INJECTION MOLDED NYLON

Material	Type of Lubricant[a]	Load, psi	Speed, sfm	PV Rating[b]	Power Consumption (FV)[c]	Running Time, hr	Total Wear, mil[d]	Coef of Friction	Comments
Sintered (sintered in lubr[e]; no other used)		135	240	32,400	3890	48	1.5	0.12	Smooth; no coef chg
		195	240	46,800	4680	24	1.5	0.10	Smooth; no ceof chg
		195	370	72,200	6500	24	1.5	0.09	Smooth; no coef chg
Injection Molded (type 6/6)	2 Drops	195	240	46,800	5150	21	2.7	0.11	Smooth; no coef chg
		195	370	72,200	8000-23,000	Failed in ½ hr	0.6	0.11-0.32	Very rough, variable
	None	52	240	12,500	8370	Failed in 3 min	20.0	0.19-0.67	Very rough; steady coef incr

[a]Lubricant (where used): Gulf Crest 55.
[b]PV = load in psi x velocity in ft per min.
[c]FV = frictional force in psi x velocity in sfm.
Source: Adapted from *Stott*.
[d]Wear based upon 24-hr tests unless otherwise noted. Values include deformation of samples.
[e]Sintering in lubricant provides a nonoxidizing atmosphere, as well as improving lubricity of the part.

hardened or surface-crosslinked to improve surface characteristics. Such treatment usually penetrates to a depth of about ⅛ in. from the surface.

Type 8 nylons have been used for impregnating and coating synthetic and natural fabrics, rubber goods, paper, leather, metals, textile threads, and fabrics for fuel cell barriers. Molded materials are suitable for seals, gaskets and packings, belting, and components requiring extremely high impact resistance.

Other types—The two types of alcohol-soluble resins produced by Du Pont cannot be crosslinked. Although soluble in phenols and lower aliphatic alcohols, they have good resistance to oils and gasoline, and excellent resistance to hot or cold aqueous alkali solutions, to oxygen, and to oxygen-containing gases, including ozone.

They are primarily intended for solution or dispersion coating. They can also be injection molded or extruded. Major applications include textile coating, jacketing for mechanical cables and ropes, sheeting, packings, seals and high impact parts. Properties are shown in Table 2.

Acknowledgments

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Fiberfil, Inc.
Firestone Plastics Co., Div. of Firestone Tire and Rubber Co.
Foster Grant Co., Inc.
Panelyte Div., St. Regis Paper Co.
Polymer Corp.
Spencer Chemical Co.

References

Stott, L. L., "Sintered Nylon," *Modern Plastics*, Sept '57.

Warriner, W. C., and Cheney, A. J., "Zytel Nylon Resin, A Versatile Engineering Material," paper presented at American Society of Mechanical Engineers meeting, June '56.

Want to reduce scrap losses in the production of sheet metal parts? This article tells you . . .

How to Evaluate Formability of Sheet Metal

by D. A. Stewart, *Aircraft Gas Turbine Div., General Electric Co.*

■ When sheet metal is fabricated into a part the metal is subjected to strains from bending, stretch forming or drawing, or more commonly a combination of these operations. These forming operations usually take place at stresses beyond the yield point of sheet metal. Since metal may fracture during forming operations and wind up 100% scrap, a designer should pre-test metal before specifying it for a part.

A number of tests are available to the designer for evaluating the formability of sheet metal. The tests are not completely accurate because they are dependent on human error; however, they serve as useful guides in determining how well a metal forms. This article describes some of these tests, especially the ones now in use at GE's Evendale plant in Cincinnati.

Three Basic Definitions

Bending occurs when forces act on a sheet to produce stresses in a cross section that are tensile on one side and compressive on the other side of a neutral axis. (For simple cases, assume that no external longitudinal forces are induced by load or supports.)

Stretch forming occurs when sheet metal is clamped at the edges of a die, the edges of the sheet not being permitted to flow into the die cavity. Metal is stretched along its longitudinal axis in combination with the bending action required to fit it to the contour of the die.

Drawing differs from stretch forming in that clamping pressure is sufficient to prevent wrinkling in the metal, yet permit it to flow under the clamps and into the die cavity as forming and bending occur.

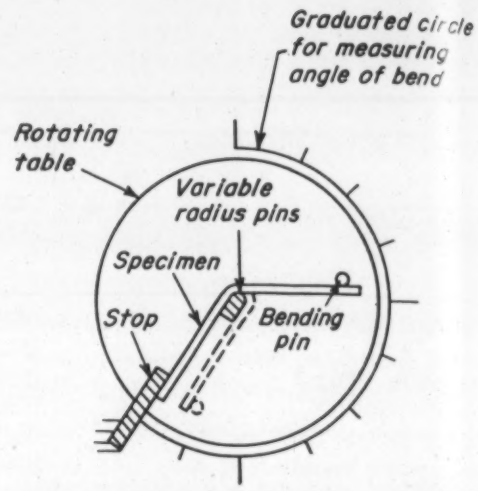
Bend tests

Bend tests are often conducted by bending a sheet metal sample back upon itself in a vise or by hammering it to the desired angle over an anvil. The tests are not dependable because they do not accurately measure the effect of such factors as metal thickness, angle of bend, and bend radius.

An improved bend test, shown schematically in Fig 1, has three advantages: bend radius is interchangeable, included angle is variable, and test equipment is low in cost. However, this test does not have the rigidity necessary for applying pressures similar to a die bending operation or for producing bend radii at any angle.

New hydraulic bend test improves accuracy . . .

A more accurate bend test than the one shown in Fig 1 is now in use at the Evendale plant. Equipment used in the test (see Fig 2) consists of hydraulically operated dies that are designed to hold 90-deg and 45-deg V-blocks with matching punches. The punches have nose radii from 0.010 to 0.250 in. which vary by increments of 0.010 in. at the small radii to 0.050 in. at the large radii.



AN EARLY BEND TEST

***Fig 1**—Schematic of a bend test that offers interchangeable bend radius.*

The bend testing machine operates by applying force to a sample to make it conform exactly to the nose radius on the punch. Picking an arbitrary starting point, samples are bent at larger or smaller punch radii until a critical point is reached. At this point a sufficient number of samples are bent to establish the smallest bend radius obtainable without cracking the sample. This procedure is followed for both 45 and 90-deg included angles. An optional test run can be run to determine the metal's ability to form a bead; this consists of bending a sample until it reaches 0 deg included angle.

Two factors should be considered when bend testing a sheet metal:

Rolling direction—A minimum bend radius should be established for both parallel and perpendicular bends, since directional properties vary with different sheet metals. Most sheet metals have greater bend strength when the rolling direction used in forming the sheet is perpendicular, rather than parallel, to the bend axis.

Edge preparation — Cracking will be more apt to occur in the middle of the bend if a sheet metal part is trimmed after form-

ing. If a part is not trimmed after forming, then minimum bend radius must be based on cracking whether it occurs at the edges of the part or in the middle of the bend.

. . . but care is still needed in crack inspection

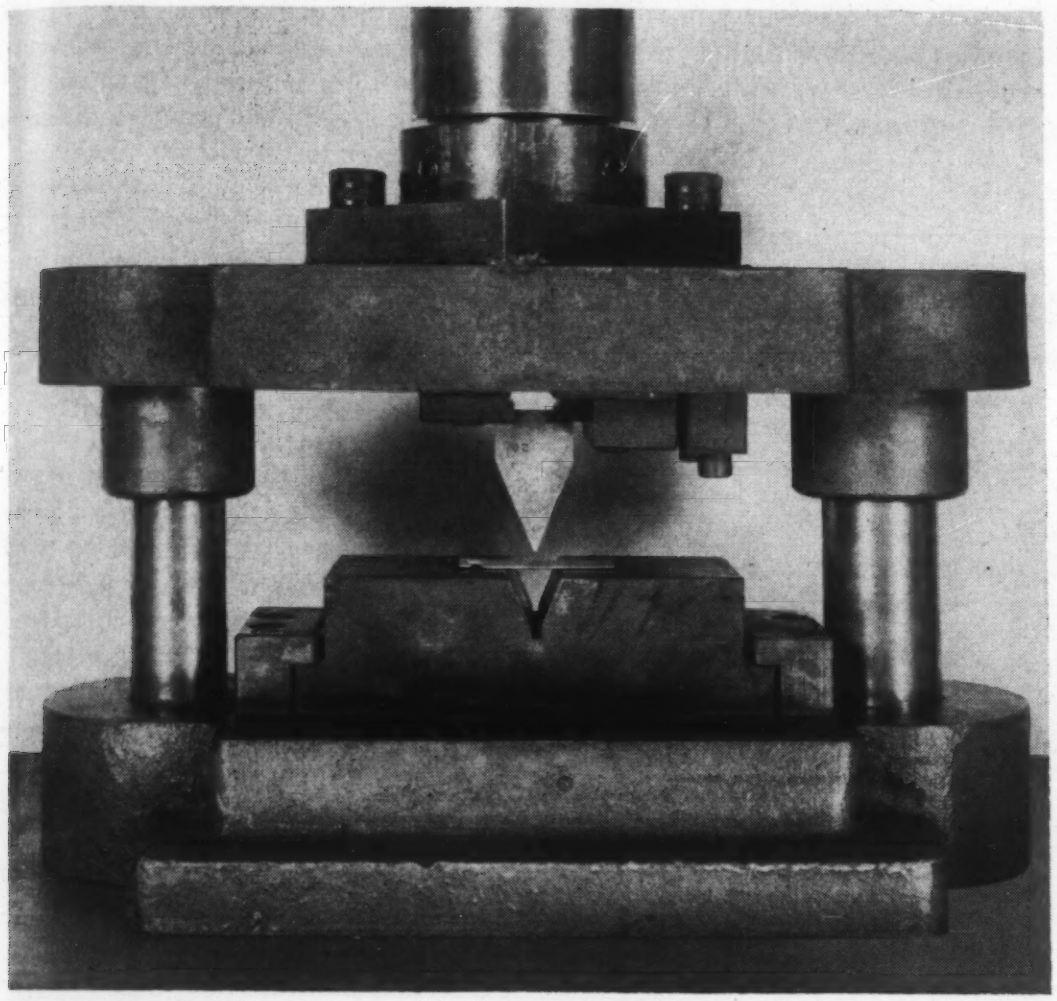
The appearance of cracks in a bent sheet metal specimen can often be misleading, as indicated in Fig 3. The specimen on the left ruptured along distinct lines and leaves no doubt as to how far the sheet metal can be bent. However, the specimen on the right developed an "orange peel" surface that prevented the tester from detecting small cracks in the metal. This orange peel appearance occurs frequently in ductile metals as the metal approaches the critical bend. It is wise to use dye penetrant as well as visual inspecting techniques when checking a bent sheet metal specimen for cracks.

Use graphs to show minimum bend radii

Once a designer has established minimum bend radii for a particular sheet metal, he can set up the data on graphs similar to those shown in Fig 4. The graphs establish minimum bend radii not only as a function of sheet metal thickness but also as a function of rolling direction and included angle.

The line on the graphs representing 50% safety factor can be used if a designer wants to design a part in which minimum bend radius is not critical. However, if the contour of the part demands an absolute minimum bend radii then the actual plotted line on the graph should be used. The designer should bear in mind that there will be a certain percentage of rejects caused by variations of individual sheets.

THE IMPROVED BEND TEST—

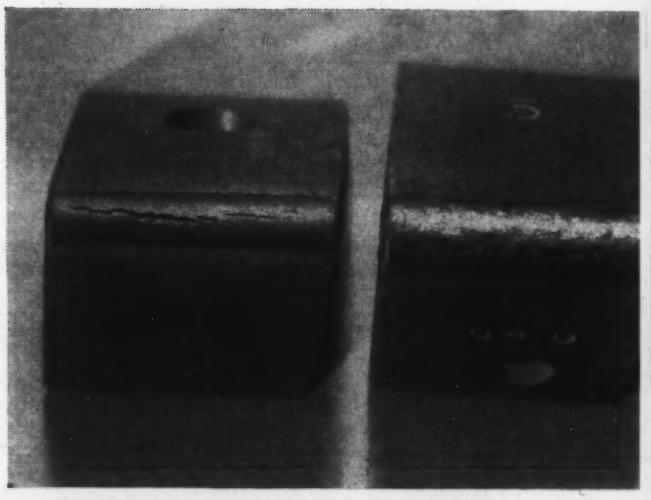


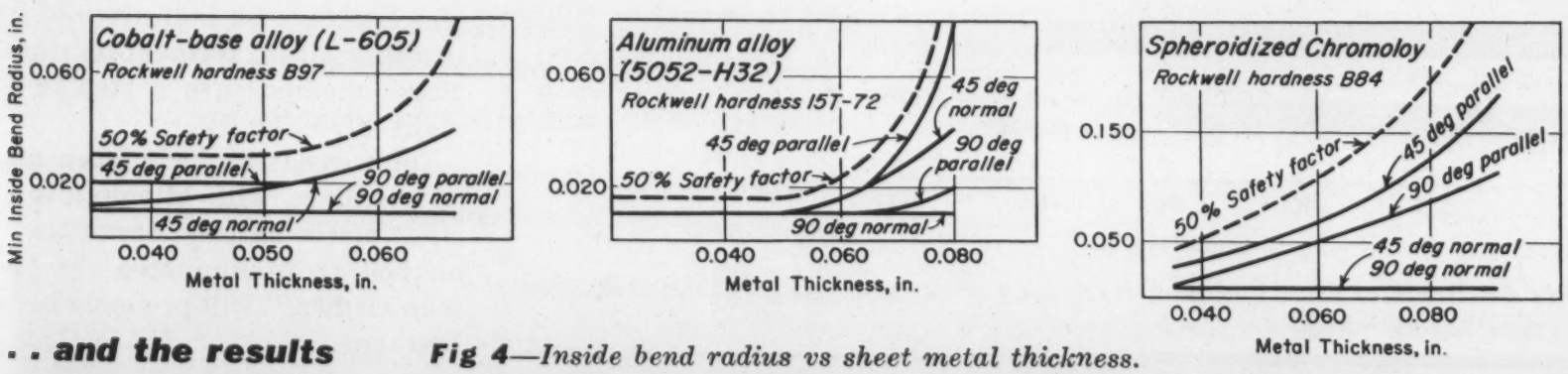
The machine . . .

Fig 2—*Hydraulic bend tester developed at GE's Evendale plant.*

. . . the specimen . . .

Fig 3—*Sheet metal can develop either distinct cracks (left) or an "orange peel" surface (right) after bending.*





. . . and the results

Fig 4—*Inside bend radius vs sheet metal thickness.*

Draw tests

The simplest and most widely used draw test is the Olsen or Erichsen cup drawing test. This test involves clamping a sheet metal specimen between a circular die and a hydraulically actuated ram. A ball or hemispherical punch is then forced upward, pushing the metal through a circular opening in the die. The size of the opening varies from sample to sample, since it is a function of sheet thickness. As the ball is forced upward, the pressure required to actuate the ram is recorded on a pressure gage. When the sheet metal begins to crack (see Fig 5) there is a sudden drop in pressure, indicating the maximum drawability of a metal. The depth of draw is continuously measured by a dial indicator that contacts the top of the cup.

The determination of end point in the Olsen or Erichsen test varies with the sheet alloy being evaluated. A work hardenable alloy has an audible snap when it breaks enabling the operator to keep a constant watch on the gage indicator and obtain a fairly accurate reading when the snap occurs. In the case of a metal that is not work hardenable, the operator must watch both the surface of the metal being deformed and the gage for any sudden drop in pressure. In either case, when the metal breaks the operator must stop the machine and take a reading in the brief instant before the ram drops away. Depth of draw readings for a particular sheet alloy may range from 0.005 in. to 0.025 in. within a group of samples taken from the same sheet and the same lot. As a rule, work hardenable alloys tend to fall within a more narrow test range than non-work hardenable alloys.

Some authorities believe machine speeds cause variations in depth of draw readings; however, tests performed in our Metal Working Laboratory indicate variations obtained with fast machine speeds are no different than variations obtained with normal machine speeds. The best way to minimize variations in depth of draw readings is to have one operator run all comparative tests or to have a group of operators trained in a set procedure.

Compare cup test data with a known material

A metal with well known drawing characteristics, such as type 321 stainless steel, should be used as a standard whenever a group or a pair of metals are compared for drawability; other less familiar alloys are then indicated as forming to a certain percentage of the known material (see Fig 6). Such a comparison gives the designer an idea of what he can expect from an alloy, but it does not tell him to what depth any specific part may be drawn.

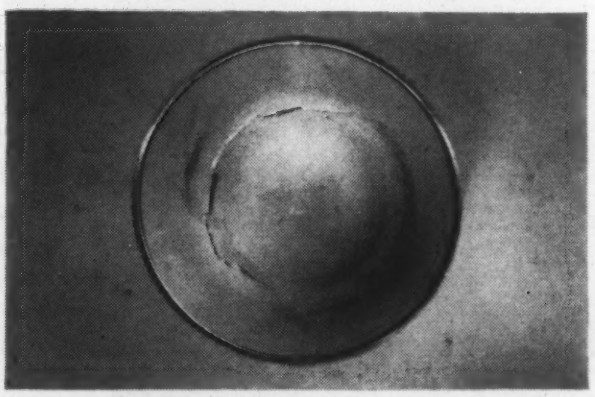
When making this type of comparison all samples should be drawn on the same machine, preferably by the same operator or at least by operators using the same technique.

Better tests are needed

In formability testing no exact formula can be given for a simplified method. There have been mathematical methods developed which give some indication of formability or a formability index. These methods are a step in the right direction.

Improved test techniques must be combined with attempts to derive mathematical formulas. A method that eliminates the "human element" will probably be the best one.

DRAW TEST—



The specimen . . .

Fig 5—*A sheet metal specimen looks like this after an Erichsen cup test.*

. . . and the results

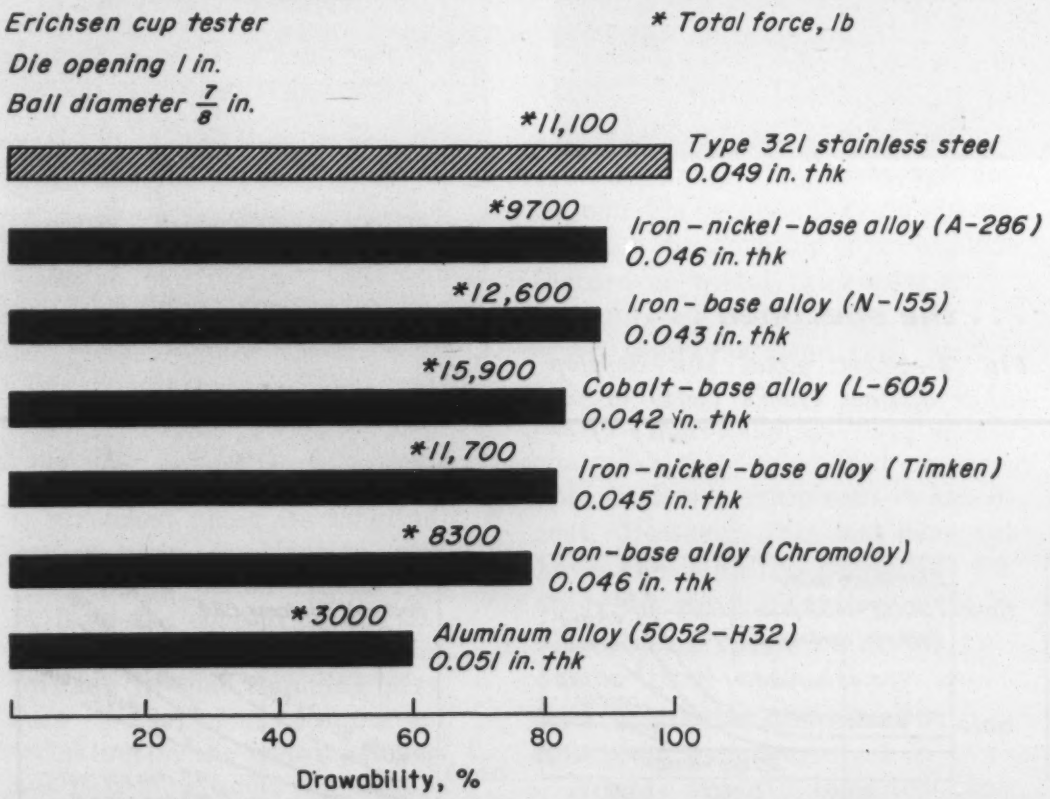
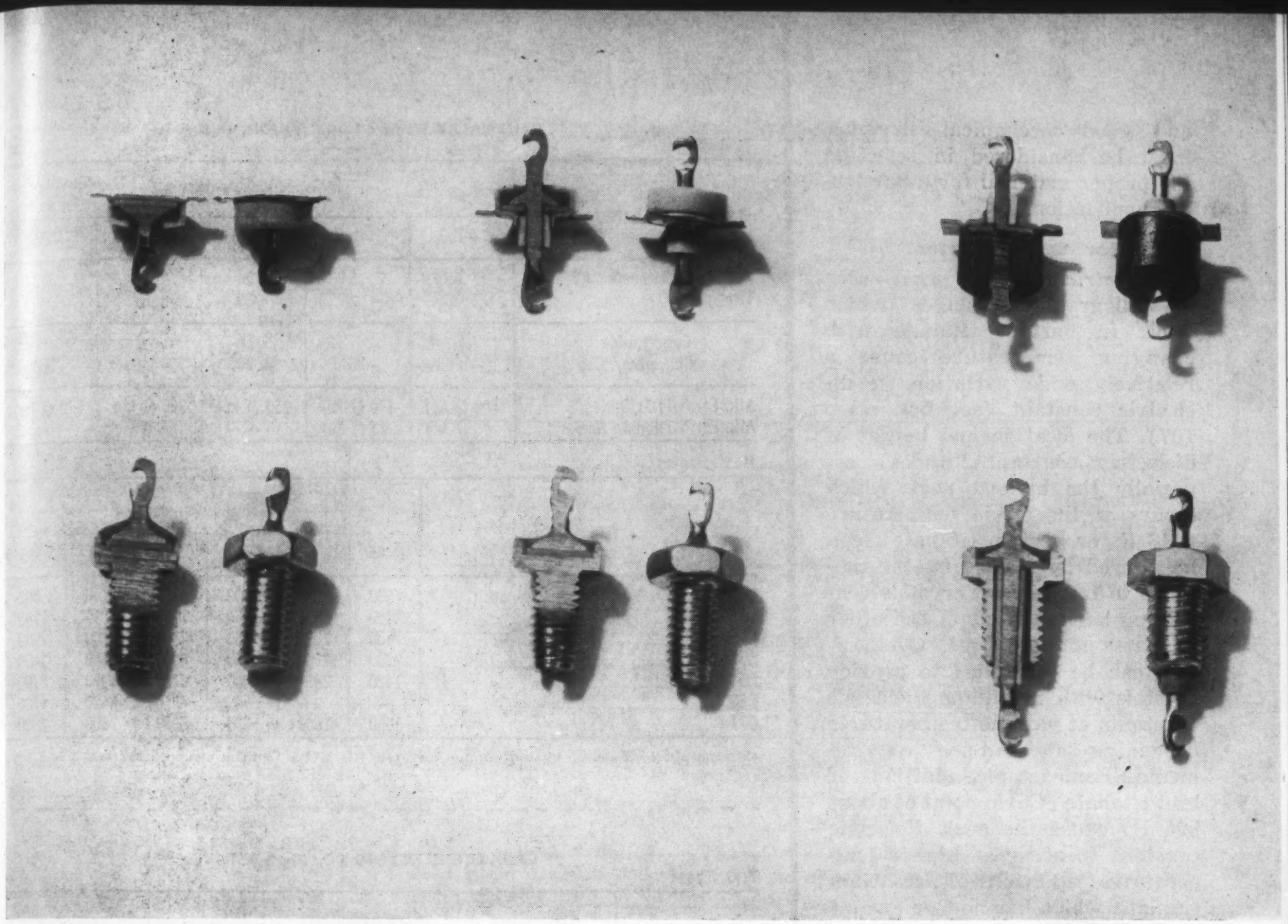


Fig 6—*Depth of draw and total force for various sheet metal alloys compared to type 321 stainless.*



Allen-Bradley Co.

Feed-through capacitor combinations.

A Guide to

Ferroelectric Ceramics

Miniature electronic devices must use efficient capacitors and transducers. Here are the properties you can expect in commercial ferroelectric capacitor and piezoelectric bodies.

by George Economos, *Massachusetts Institute of Technology*

■ Barium titanate and modified barium titanate compositions are the most widely used ferroelectric ceramics. The modifications of barium titanate have provided bodies with an extremely wide range of electrical characteristics.

The major uses for ferroelectrics are 1) capacitors, and 2) transducers. In capacitors the primary desirable property is a high dielectric constant (k); in transducers, the primary property is a high efficiency in converting from one type of energy to another, as measured by the coupling coefficient (k_{33}).

In addition to these primary requirements, of course, other properties, such as temperature and frequency stability, high dielectric strength, high resistivity

See next three pages for exclusive tabular summaries of the properties of commercial ferroelectrics →

and good mechanical strength, must be considered in selecting the proper material for a particular application.

Capacitor ferroelectrics

Dielectric constant peaks—The crystallographic changes which occur in barium titanate with changing temperature cause a relatively wide variation in dielectric constant (see box on p 107). The location and height of dielectric constant "peaks," especially the highest peak which occurs at the Curie temperature (248 F for barium titanate), can be altered by modifying the material to form mixed crystals containing barium titanate and other titanates and additives. Composition can be controlled to provide crystals with maximum dielectric constants at various temperatures depending on end-use requirements. For example, additions of lead titanate (Curie point of about 895 F) cause the peak dielectric constant to occur at higher temperatures; additions of strontium titanate, which has no Curie point down to liquid helium temperatures, moves the peak toward the lower temperatures.

The location and shape of such peaks are critical in determining the type of material to be used. Ideally, a flat, high curve, indicating high dielectric constant values over a relatively wide temperature range, is more desirable than relatively sharp peak values. In commercial materials, complex combinations of titanates, zirconates, stannates, bismuthates and other oxides are used to achieve stable high values in the room temperature range. Typical variations of peak values caused by these additions are shown in Fig 1.

Note that in flattening out the peak k values, lower values are obtained. At present, this compromise must be made where a high degree of temperature stability is required.

The recent emphasis on higher operating temperatures has concentrated interest on lead titanate-containing compositions; however, numerous problems have limited

CENTRALAB DIV., GLOBE UNION, INC.

T. C. Bodies

Capacitance Chg, ppm/°C ➡	Capacitance (1 mc)				
	+100	−100	−300	−500	−700
Rare Earth Titanate "A"	35	54	76	89	113
Titanate "C"	18	24	30	37	45
Capacitance Chg, ppm/°C ➡	**−1000**	**−2000**	**−3000**	**−4000**	**−5000**
Alk. Earth Ti-Zr Series	100 (1 kc)	170 (1 kc)	250 (1 kc)	360 (1 kc)	510 (1 kc)
Alk. Earth Titanate Series	40 (1 kc)	75 (1 kc)	—	—	—

H. K. Bodies

Temp, F ➡	Dielectric Constant					
	−65	5	40	77	115	185
D4[a]	500	500	500	500	500	500
D15[a]	1200	1250	1250	1250	1250	1250
D22[a]	2000	2300	2350	2300	2200	2000
D32[a]	2700	3800	4050	4000	3500	2400
D51[b]	1420	2950	4400	6200	5900	2700
D52	—	—	—	4550	6400	4700
D71[c]	1000	1800	5500	8900	7500	2300

[a]Temperature-stable. [b]Room temperature tan δ is 1.1%. [c]Room temperature tan δ is 1.7%.

SPRAGUE ELECTRIC CO. (Cera-Mite)

T. C. Types

Grade[a]	Capacitance Range Available, μμf	Capacitance Tolerance (room temp), %	Dissipation Factor (tan δ), %	Insulation Resistance, megohm[b]
NPO to N750	1 to 730[c]	±2	0.1 max at 1 mc;	10,000
N1500 to N2200	10 to 1640[d]	±2	0.2 max at 1 mc for < 10 μμf	

H. K. Types

Capacitance Range Available, μμf	Capacitance Tolerance (room temp), %	Dissipation Factor (tan δ)	Insulation Resistance, megohm[b]
100-800	±20 and ±10	2% max at 1 kc	>10,000
0.001-0.005	±20 and ±10		
0.01-0.1	+80 to −20 for lower ranges; +80 to −30 for 0.1 μf		

[a]Letters "N" and "P" denote negative and positive capacitance change; numerals denote change in ppm/°C.
[b]At 77 F, after 2 min at 180 v (d.c.). [c]1000-v (d.c.) rating. [d]500-v (d.c.) rating.

AMERICAN LAVA CORP. (AlSiMag)

H. K. Bodies[a]

Grade ⬇	Dielectric Constant (1 kc at 5 v max)	Capacitance Change (1 kc at 5 v max), %/°C				
		25 F	50 F	77 F	130 F	185 F
T-148B	1200-2000	—	—	0	−18	−16
T-163	900-1300	+8	+ 4	0	− 2	+16
T-169	1000-1200	—	+11	0	− 9	+14
T-120B	1100-1400	—	+14	0	− 9	− 1

[a]Power factor for all grades is 1.5% max.

ALLEN-BRADLEY CO.

Grade	Dielectric Constant
T. C. Bodies[a][b]	
P100, P30, NP0, N80, N220, N470 N750	15-80
H. K. Bodies[c]	
KS800	800
K1000	1100
KS1200	1200
KS1700	1700
K3000	3500
K6000	7000

[a]For all T.C. grades: power factor (1 mc) is 0.1%; dielectric strength (d.c.) <500 v/mil; and resistivity (77 F) is 10^{12} ohm-cm.
[b]"P" denotes positive and "N" negative capacitance change; digits indicate change in ppm/°C from −65 to 185 F.
[c]For all H.K. grades: power factor (1 kc) is 1%; dielectric strength (d.c.) >250 v/mil; and resistivity (77 F) $>10^{12}$ ohm-cm.

Properties of Commercial Capacitor Ferroelectrics

RADIO MATERIALS CORP. (Discaps)

T. C. Bodies

Grade[a]	Capacitance Range, μμf	Temperature Coefficient, % of 68-F Capacitance				
		−5 F	25 F	70 F	105 F	185 F
P-100	1-20	−0.4	−0.3	0	+1	+7
NPO	2-150	+0.2	+0.1	0	−0.1	−0.3
N-80	2-150	+0.3	+0.2	0	−0.3	−0.6
N-220	3-175	+1	+0.6	0	−0.4	−1.5
N-470	3-240	+2.2	+1.3	0	−1	−3.3
N-750	5-350	+3.2	+1.8	0	−1.5	−4.8
N-1400	15-560	+8.2	+5	0	−3.5	−9.8

H. K. Bodies[b]

Grade	Capacitance μf	Dissip Factor (tan δ), %	Working Voltage (d.c.), v	Capacitance Tolerance (room temp), %
B, U	0.00015-0.02	1.5 (1 kc)	1000	Varied
High Voltage	0.000331-0.01	1 (1 mc)	2000	±20
	0.000241-0.005	1 (1 mc)	3000	±20
	0.000181-0.001	1 (1 mc)	4000	±20
	0.000131-0.001	1 (1 mc)	5000	±20
	0.000101-0.001	1 (1 mc)	6000	±20
JF, JL	0.00015-0.01	1.5 (1 kc)	1000	±10 and ±20, respectively
LV, BT	0.005-0.1[c]	3 (1 kc)	100	±40 and ±15, respectively

[a]Designation: P = positive, N = negative; numerals denote capacitance change in parts per million per °C.
[b]Insulation resistance: >7500 megohms. [c]μμf.

MURATA MFG. CO., LTD. (Ceramo-C)

T. C. Bodies[a] **H. K. Bodies**[b]

Grade	Dielectric Constant		Dissip Factor (10^4 tan δ)		Temp Coef, ppm/°C	Dielec Str, kv/mm	Grade	Dielectric Constant		Dissip Factor (10^4 tan δ)	
	1 kc	1 mc	1 kc	1 mc				1 kc	1 mc	1 kc	1 mc
C	18-20	18-20	3-20	0.5-3	+17 to −17	10-20	YY 1	1500	1300	150-200	100-150
U	85	85	3-10	3-10	−358 to −468	10-20	YZ 2	3000	2500	100-150	50-100
AA	6	6	8-12	3-5	66 to 88	20-30					

[a]Capacitance range: 0.4 to 1100 μμf; resistivity: 10^{12} megohm-cm.
[b]Capacitance range: 300 to 10,00 μμf; resistivity: 10 meghom-cm; dielectric strength: 5-10 kv/mm.

ERIE RESISTOR CORP. (Ceramicon)

T. C. Bodies **H. K. Bodies**[c]

Grade[a]	Dielectric Constant (77 F)	Power Factor (max; 1 mc), %	Dielectric Strength, v/mil[b]		Grade	Dielectric Constant (min; 77 F)	Breakdown Strength, v/mil[d]		Capacitance Change, %	
			185 F	255 F			185 F	255 F	−65 to 185 F	50 to 150 F
P100	15	0.1	75	37.5	K250AB	244	65	32	+5, −7.5	+5, −7.5
N030	31	0.1	75	37.5	K1200FA	1000	50	25	±10	±10
N150	41	0.1	75	37.5	K1200HA	1200	100	50	—	±3.3
N330	50	0.1	75	37.5	K3500	3500	50	25	+22, −82	+22, −56
N750	82	0.1	75	37.5	K6000AA	5200	40	20	+22, −82	+22, −82
N2200	160 min	0.2	100	50						
N4700	550 min	0.2	50	25						

[a]Designation: P = positive, N = negative; numerals denote capacitance change in parts per million per °C (77 to 185 F).
[b]1000-hr life test voltage. [c]Power factor for all grades: 1.5% (1 kc). [d]1000-hr life test voltage.

Properties of Commercial Piezoelectric Ceramics

MURATA MFG. CO., LTD.

Grade	Dielec Const (1 kc)	Dissipation Factor (tan δ), %	Coupling Coefficient (k_{33})	Density, lb/cu in.
A	1800	1	0.32	0.198
B	740	0.6	0.24	0.194
C	460	0.4	0.18	0.191

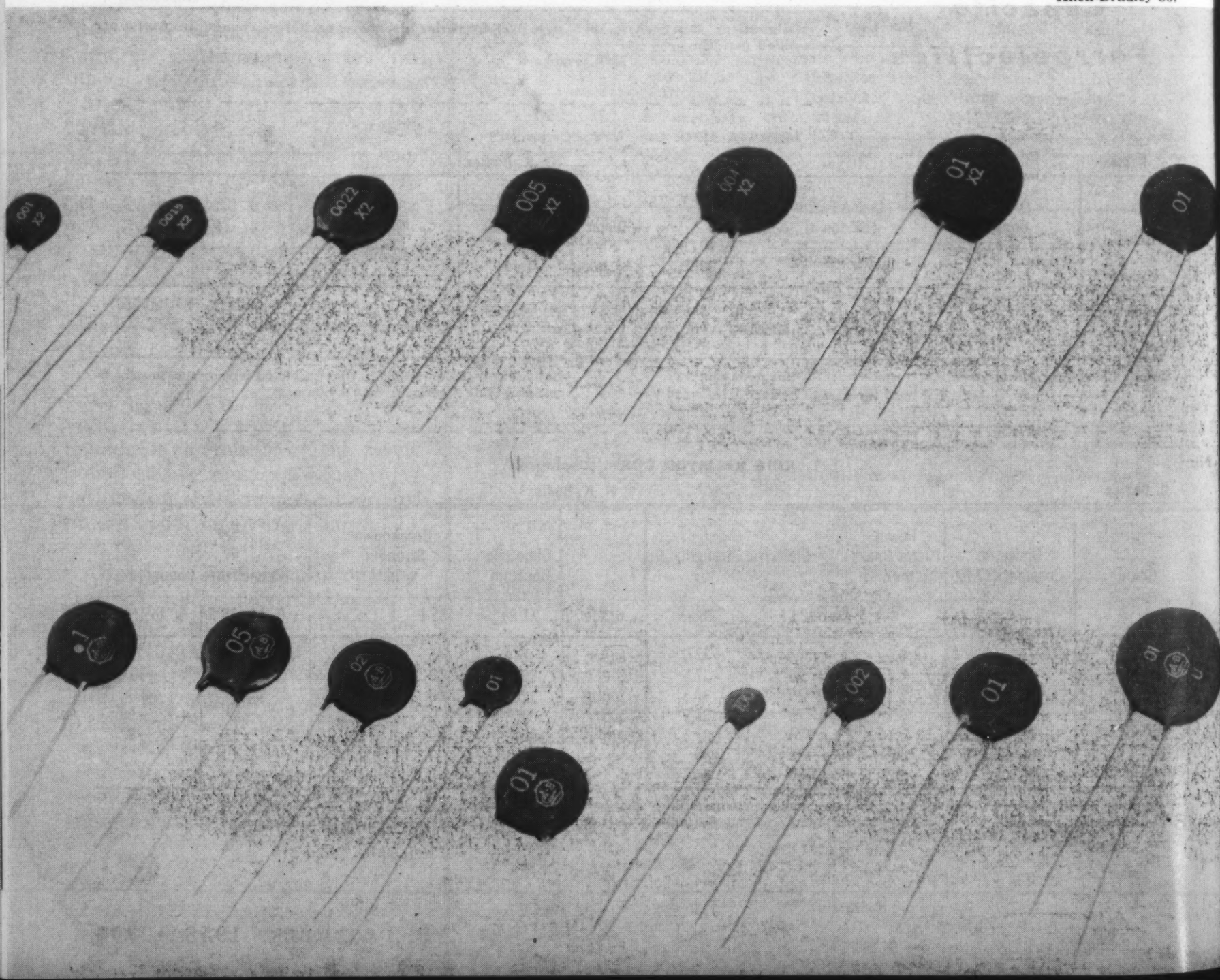
AMERICAN LAVA CORP. (AlSiMag)

Grade	T_c, F	k_{31}[a], %	k_{33}[b], %	d_{31}[c], 10^{12} coulombs/newton	d_{33}[d], 10^{12} coulombs/newton	$f_r x$[e], kc-in.	$f_r x d$[f], kc-in.
T-148B	240-255	15-32	17-40	20-80	60-180	91-96	99-113
T-163	240-255	15-30	20-45	20-80	60-180	99-103	117-121
T-169	~260	26-31	23-31	~76	~190	—	110-116
T-120B	265-280	26-42	15-45	56-82	45-205	93-100	99-118

[a]Transverse coupling coefficient.
[b]Thickness coupling coefficient.
[c]Transverse piezoelectric constant.
[d]Thickness piezoelectric constant.
[e]Resonant frequency constant; thickness (t) less than radius (r).
[f]Resonant frequency constant; radius (r) greater than thickness (t).

Typical titanate capacitors.

Allen-Bradley Co.



their use. Two of these problems are: 1) high volatility of the lead oxide causes compositional changes difficult to control, and 2) a fired body may be quite porous and have a differential lead concentration from the surface to the interior. Also, during manufacture, furnace refractories can be seriously deteriorated by the lead oxide vapors.

Types and properties—Two basic types of high-dielectric-constant ceramic capacitors are produced today: 1) the "temperature compensating" (T.C.) type, and 2) the "high k" (H.K.) type. The T.C. type is useful for its characteristic of linear temperature variation, required for temperature compensation in certain electronic circuits. The H.K. type is desirable for its high storage capacity. All other types of capacitors are variations of these two designed to emphasize specific features of importance for specific uses.

The accompanying tables give selected property data on both T.C. and H.K.-type bodies supplied by various producers. As can be seen from the data, not all producers agree on what properties are basic. Also, other factors, such as effects of temperature cycling, effects of aging, and test conditions used, should be considered. Producers should be consulted before final evaluation and selection of materials is made.

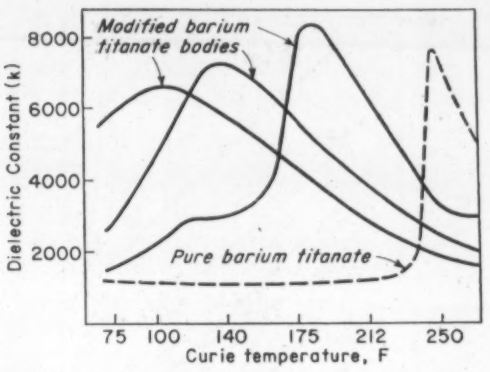


***Fig 1**—Typical effects of modifications on the dielectric constant of barium titanate compositions.* *(Allen-Bradley Co.)*

New ferroelectrics—Various ti-

Ferroelectricity Explained

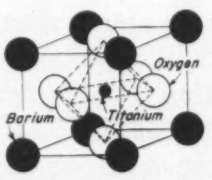
What is a ferroelectric?

A ferroelectric is a material that exhibits a nonlinear response of the polarization to an applied field of varying amplitude. In this article, the term "ferroelectric" is used rather loosely because the high dielectric constant value is the only criterion for the existence of the ferroelectric state in these materials. (A better proof would be the occurrence of hysteresis in the polarization vs applied field characteristic.)

Ferroelectricity is generally described as the electrical analogue of ferromagnetism (see "A Guide to Ferromagnetic Ceramics," M/DE, Sept '58, p 96), which accounts for the prefix "ferro-." The behavior of the two types of materials is very similar. The difference lies in the fact that ferromagnetism stems from interactions in the lattice which cause alignment of spinning electrons of ions, whereas ferroelectricity stems from the spontaneous polarization of ions in a compatible lattice. In ferroelectrics an applied electrical field causes the spontaneously polarized domains to shift and follow the same sequence as occurs in ferromagnetic materials to produce the familiar hysteresis loop. Thus, ferroelectrics are also nonlinear dielectrics.

Barium titanate

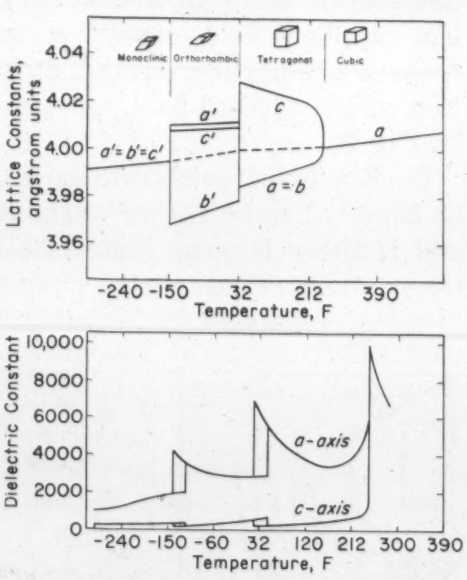
Barium titanate ($BaTiO_3$), the simplest and most commonly and successfully used ferroelectric, belongs to a larger class of compounds called perovskites. The ideal perovskite lattice is a cubic close-packed arrangement of barium and oxygen ions, as shown in the accompanying sketch. A barium ion is located in each corner and an oxygen ion in the center of each face of a cube. The octahedron of oxygen ions forms the interstice for the titanium ion. Substituting other ions (such as other titanates, zirconates and stannates) for the barium or titanium or both, or even changing the temperature, causes changes in the structure.



Perovskite unit cell.

Barium titanate goes through a series of lattice transitions as temperature decreases, as shown in the accompanying curve. At room temperature it is tetragonal (connected with the spontaneous polarization of the ions along the "c" axis) and is about 1% out of the high temperature (stable above 248 F) cubic form.

One of the earliest and most easily visualized theories on the origin of ferroelectricity in barium titanate is the "rattling" ion hypothesis of *Megaw*. The ions at the corners of the unit cell are held to be the key to the observed behavior. When strontium ions occupy these positions, a quite perfect packing of all the ions provides cubic symmetry. When the larger barium ions occupy these positions, they expand the oxygen lattice, giving the titanium ion more space than it needs, thus permitting it to "rattle." Upon cooling from a higher temperature, a shift of the titanium ions occurs when the interionic forces overcome the thermal agitation. The movement of the titanium ions causes a shift of the oxygen ions closest to these polarized ions and, through a feedback mechanism, results in spontaneous polarization and domain formation.



***Lattice transitions** (upper figure) and corresponding variations in dielectric constant (lower curves) which occur in barium titanate with changing temperature.* (Von Hippel)

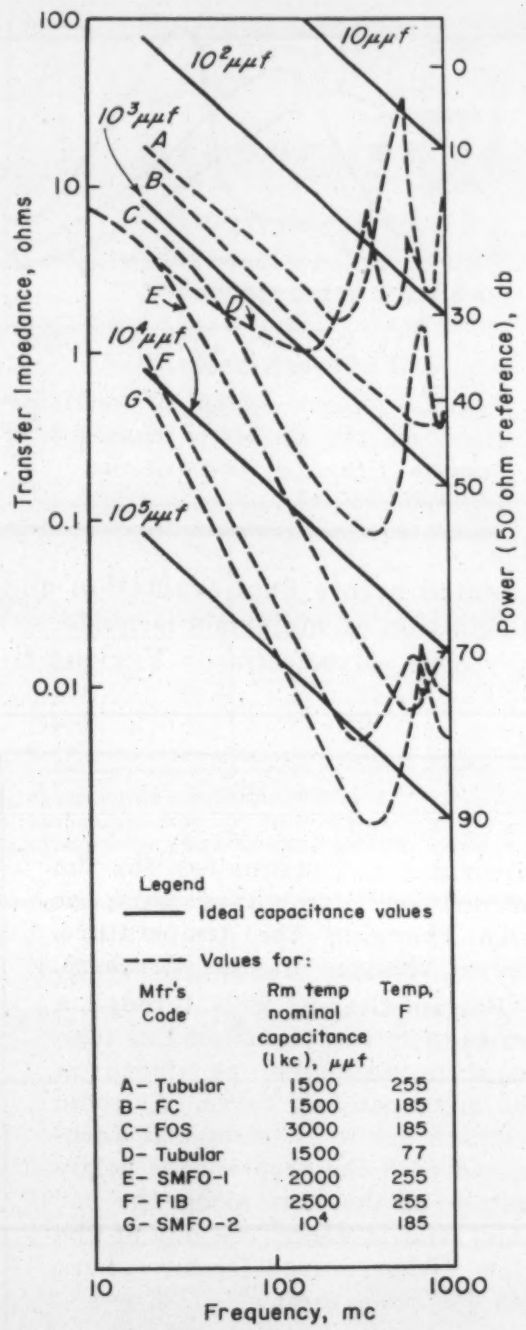


***Fig 2**—Typical feed-through response of capacitors compared with ideal values.* (Allen-Bradley Co.)

tanates, zirconates, stannates and combinations of these have been studied to find new useful ferroelectric compounds. Except for a few interesting antiferroelectric effects, no startling results of commercial importance have occurred. Primary uses for these materials are as additives to barium titanate. Some tantalates and niobdates have exhibited ferroelectricity, but they seem to offer no property benefits as compared with currently used materials.

The rectangular hysteresis loop common to some ferrites, and of use in computer design, is a rarity in ceramic ferroelectric materials. Single crystals show some promise in this regard, but they do not seem to offer much advantage over the magnetic materials now being used.

An interesting recent development is the use of stacked disks of high k materials to form efficient feed-through capacitors. Even more recent is the use of combinations of ferroelectric titanates and ferromagnetic ferrites for components useful at very high frequencies. Fig 2 shows the behavior of some of these units as compared with ideal capacitance values.

Transducer (piezoelectric) ferroelectrics

Piezoelectric ceramics are those materials in which the application of a stress produces an electrical charge, and vice versa. The mechanical stress applied to a piezoelectric material can be of any type, e.g., compressive, torsional, tensile or thermal (pyroelectric).

The ferroelectric domains of barium titanate, as it comes from the sintering furnace, are randomly oriented. Such random orientation cancels the polarization vectors. Thus, to obtain maximum polarization of the body in the desired direction (which provides marked increases in the piezoelectric response to an applied field) the body must be "poled" by heating it to temperatures above the Curie temperature and cooling in an applied d.c. field. The applied field causes a net domain orientation in the direction of the applied field, as shown in Fig 3.

Such a poled configuration can be expected to be rather unstable, and if there is some ionic mobility or stress release a slow change to a more favorable energy condition should result. This change is known as aging, and the resultant condition is generally attributed to an exponential change of the forced domain configuration to a more random, compensated form.

The most desirable feature of a piezoelectric transducer element is a high efficiency between the applied field and the mechanical response, as measured by the coupling coefficient, K_{33}. Results of a recent investigation show that a high dielectric constant is not necessarily the criterion for best piezoelectric response; high density appears to be more important.

The accompanying tables show representative properties of piezoelectric bodies produced by two manufacturers.

Where they're used—Piezoelectric materials are used quite extensively commercially. Titanate pick-up-heads for recording reproduction are commonplace. Titanate ultrasonic vibrators are used for special cleaning tasks, for mixing plastics with accelerators, and for numerous acoustical and mechanical purposes.

Acknowledgment

The author wishes to thank all those who so generously supplied data for this article. Special acknowledgment is made to various members of the Allen-Bradley Company for their assistance and suggestions.

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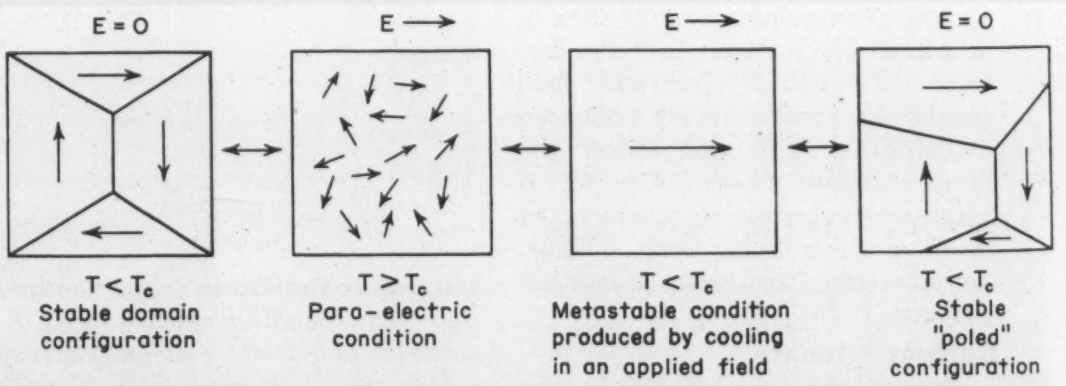
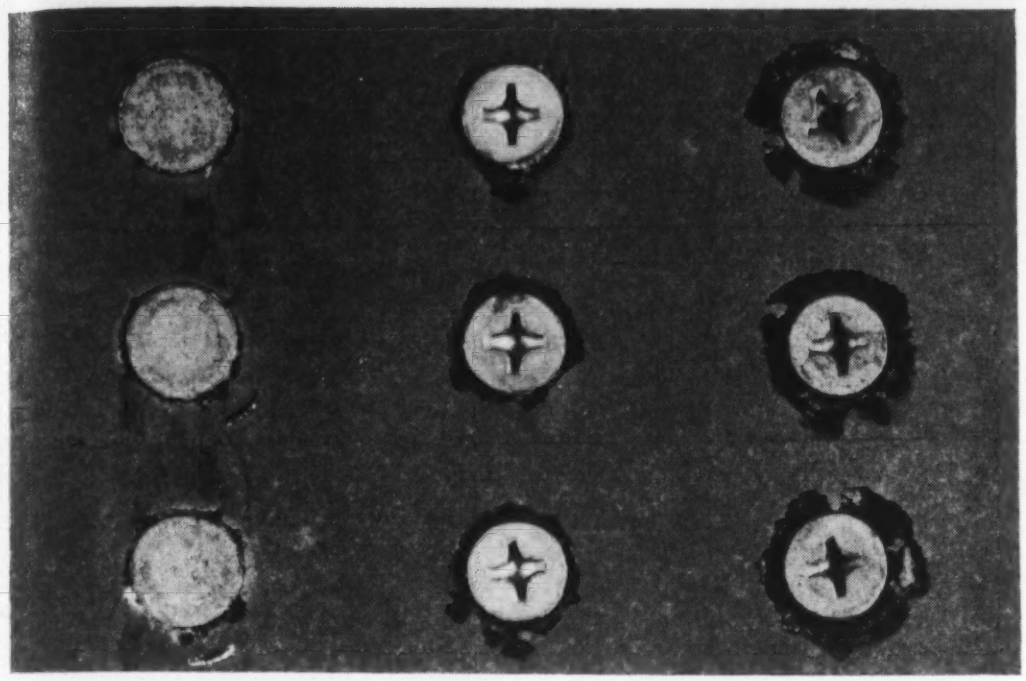


***Fig 3**—Schematic representation of "poling" in a piezoelectric crystal, showing domain orientation during each step of application of the applied d.c. field.*



Comparison of corrosion *produced by three different screws on HM21XA magnesium after 48 hr of salt spray testing.*

Unless properly protected or insulated, magnesium surfaces can be a potential source of corrosion. This article tells . . .

Three Ways to Avoid Corrosion in Magnesium

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering,* and **John Stevens,** *Dow Chemical Co.*

1. Protect the surface

Surface treatments—Corrosion of magnesium is usually accompanied by the formation of alkali deposits on the metal surface (see box on p 110 for a description of how these deposits are formed). Since alkalis destroy adhesion, these deposits can destroy the usefulness of protective coatings. Surface treatments normally applied to metals provide an acid or slightly neutral surface which promotes the adhesion of subsequent topcoats. Consequently, treatments for magnesium should provide an acid or neutral surface as well as being alkali resistant, i.e., they must not be stripped by alkalis.

The chromate surface treatments used on magnesium provide acid surfaces but are not alkali resistant. Conversely, although they have better wear resistance, the alkaline anodic treatments are alkali resistant but they do not provide the acid surface required for paint adhesion. Briefly, the characteristics of the various types of surface treatments are:

1. Provide acid surface but are not alkali resistant: Dow Nos. 1, 7, 8, 9, 10, 15, 16 and 18, 19, and Iridite No. 15.

2. Are alkali resistant but provide no acid surface for paint base: Dow Nos. 12 and 14, HAE, and Manodyze.

The only treatment which provides both alkali resistance and an acid surface is Dow No. 17. However, the alkali resistance of the treatments in 1 above can be built up by using a wash primer based on polyvinylbutyral resins. The polyvinylbutyral vehicles used in formulations specified in MIL-G-15328A or MIL-C-8514 (Aer) provide a good degree of alkali resistance.

Conversely, the paint adhesion of Dow Nos. 12 and 14, HAE and Manodyze treatments can be substantially increased by using an acid post-treatment. Treatments such as dichromate or acid fluoride dip neutralize any residual surface alkalinity. In some cases, these post-treatments are normally considered as part of the original surface treatment process.

Paints and primers—Except for certain experimental primers now under development, no primer or pigment is good enough to completely inhibit and prevent corrosion of magnesium. Nevertheless, some coating systems are quite adequate in preventing atmospheric or salt spray corrosion.

It is especially important that organic coatings used over the above surface treatments have good alkali resistance. For this reason paints based on vinyl and epoxy resins are particularly recommended. The effect of pigments on the inhibition of corrosion should also be considered when selecting a primer. Soluble zinc chromate is currently the most popular pigment. However, strontium chromate and insoluble zinc chromate, in addition to inhibiting corrosion satisfactorily, have longer life and permanence because of their insolubility. Consequently, these two materials are preferred even though satisfactory

performance can be obtained with a soluble zinc chromate primer.

Plating — Electroplating and electroless plating can also be used to protect magnesium from corrosion. However, because of its comparatively high cost, processing problems, etc., plating is not very widely used for providing corrosion resistance alone. Its use is limited to applications where other properties are required, such as solderability, wear resistance, RF grounding and decoration.

2. Use compatible materials wherever possible

Magnesium-to-magnesium—For all practical purposes, galvanic corrosion between any two magnesium alloys is negligible. However, for best results magnesium contact surfaces should be given one or more coats of a chromate-pigmented primer.

Magnesium-to-dissimilar metals—In addition to using a protective paint film, electrolytic corrosion between magnesium and dissimilar metals can be prevented by:

1. Using metals that have the best compatibility with magnesium.
2. Electroplating dissimilar metals with metals that are compatible with magnesium.
3. Separating the metals so that the corroding medium cannot complete an electrical circuit.

Fortunately, magnesium is completely compatible with many aluminum base alloys that contain magnesium. These aluminum alloys, when coupled to magnesium, exhibit polarization characteristics that reduce potential differences to a minimum and prevent electrolytic corrosion from occurring. Compatibility is mainly determined by the constituents in the aluminum alloy. Iron, copper and nickel tend to destroy compatibility; titanium has little effect; and magnesium promotes compatibility.

The most important aluminum alloys recommended for use with magnesium are: 5052 (sheet), 6061 (extrusions), AM5220 (castings) and 5056 (rivets). Recent results show that 5056 aluminum rivets have very good structural and corrosion properties when used at room as well as high temperatures. Conventional rivets, blind rivets, blind bolts and blind nuts are available as either standard or special items in the 5056 or 6061 aluminum alloys. Several quick release fasteners can be obtained with 5056 or 5052 aluminum alloy grommets.

In general, the metals that tend to corrode magnesium when coupled to it under corrosive conditions are: carbon and alloy steels, stainless steels, titanium, brass, copper, monel, and aluminum alloys 2024, 2024 Alclad, 7075, 7075 Alclad, and 3003. However, in most cases small parts made of these metals can be used with magnesium if they are coated with an electroplate compatible with magnesium.

Current tests show that tin electroplates are more compatible with magnesium than are cadmium electroplates. The photo on p 109 shows the effects of three different unpainted systems on an HM21XA magnesium alloy (treated with Dow No. 17) after 48 hr of salt spray testing. The screws on the left, made of a 5056 aluminum alloy cause relatively little corrosion damage to the surrounding magnesium; the tin-plated steel screws in the middle cause some attack; whereas the cadmium-plated steel screws on the right cause severe attack. Although the tin electroplate appears to be only partially compatible with unpainted magnesium, the compatibility of the electroplate can be materially increased by coating it with an alkali resistant epoxy or vinyl paint.

In general, a tin plate is superior to a cadmium or zinc plate when the cathode area is large, if it is unpainted, or if it is painted with an alkali-sensitive system. However, a tin plate is not as good as a cadmium or zinc plate when the cathode area is painted with an alkali-resistant epoxy or vinyl system.

Magnesium-to-wood—This type of contact presents an unusual problem because of the absorbent characteristics of wood. If wood becomes wet it can hold water in contact with magnesium for long periods. As the water is soaked up, the natural acids of the wood tend to leach out and cause corrosion of the magnesium. To prevent moisture absorption the wood should be sealed with a paint or varnish. In addition, the magnesium contact surfaces should be given one or more coats of a chromate-pigmented primer.

How Magnesium Corrodes

Corrosion of magnesium is caused by the presence of an anode (in this case the magnesium surface), a continuous liquid path or electrolyte, and a cathode. The cathode may be any metal that has a lower potential than magnesium. Corrosion starts at the anode where magnesium in contact with the electrolyte goes into solution, leaving a surplus of electrons on the metal surface. As the result of the difference in potential, these electrons flow to the cathode where they react with water in the electrolyte to produce alkali deposits. These deposits may provide a self-healing effect in preventing corrosion but usually they have an adverse effect on the adhesion of subsequent topcoats.

3. Design joints properly

Effect of fastener materials — Careful attention to joint design and selection of fastener materials is essential in preventing corrosion of magnesium. Rivets of 5056

aluminum are particularly recommended. Also, 6053 and 6061 aluminum rivets, in that order, are almost as compatible with magnesium and may be used as substitutes for 5056. In all cases rivets should be anodized or chemically treated prior to use.

The 6061 aluminum alloy is particularly recommended for bolts and hardware. Also, under cadmium-plated steel bolts best results are obtained by using 5052 washers. Joints should be designed carefully in such a system and, as shown in Fig 1, the assembly must be located so that corrosion-producing electrolytes do not bridge the washer, as in the bottom groove of flooring.

Steel and copper rivets, as well as steel, nickel, aluminum (other than 5056, 6061 or 6053) and brass bolts and screws, should not be used directly against magnesium. In general, a tin, zinc or cadmium plate on these parts is recommended, followed by a chemical treatment plus an alkali resistant epoxy or vinyl coating. Plating only retards and does not completely prevent galvanic corrosion.

Insert design—In most cases inserts used in magnesium should be plated with tin, zinc or cadmium. Naturally, no special protection is required if a dissimilar metal insert will not be exposed to the corrosive medium. If service conditions are severe, then an annular groove (Fig 2) should be provided and filled with calking compound. This groove should preferably be formed by machining the insert (A), but usually the small size of the insert makes it necessary to counterbore the groove in the magnesium (B).

Use of tapes—Electrolytic corrosion can also be prevented by using nonabsorbent tapes or sealing compounds in joints. Vinyl, Mylar and organic rubber tapes in particular are recommended. Final choice is governed by the particular assembly and protective requirements. Because of their wicking action, cloth-supported tapes should not be used.

Preventing electrolyte bridging—Typical examples of how magnesium can be separated from dissimilar metals are shown in Fig 3. It is especially important that the sealing materials in highly stressed joints remain nonconductive in use and that they extend out from the joint sufficiently to prevent bridging of the electrolyte. Fig 4 shows typical examples of how tapes and drain holes should and should not be used. The joint at the left will definitely corrode because liquids can bridge the aluminum angle and the magnesium sheet. The center angle has a tape separator but the tape does not extend far enough on the left side to prevent bridging. However, the tape on the right side of the joint extends far enough so that a drain hole can be drilled through the tape. The angle on the right is a good design in that it incorporates a drain hole and also has the tape wrapped up the sides of the angle to prevent bridging.

Minimize corrosion by | Proper choice of materials Good joint design

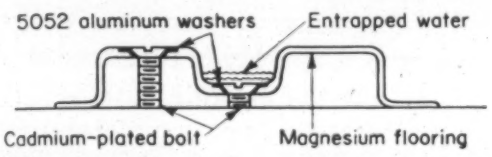


***Fig 1**—Wherever possible use 5052 aluminum washers to separate bolts and magnesium structure. However a washer cannot prevent corrosion if it is bridged by entrapped moisture.*

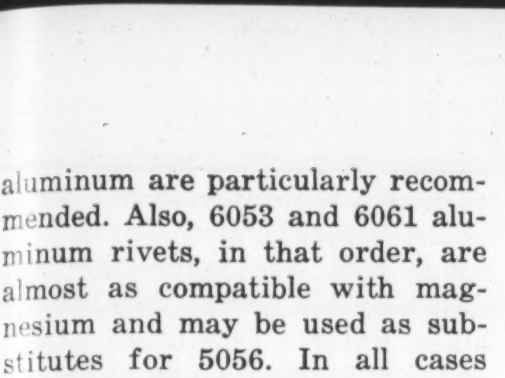


***Fig 2**—Provide inserts with an annular groove filled with a calking compound.*

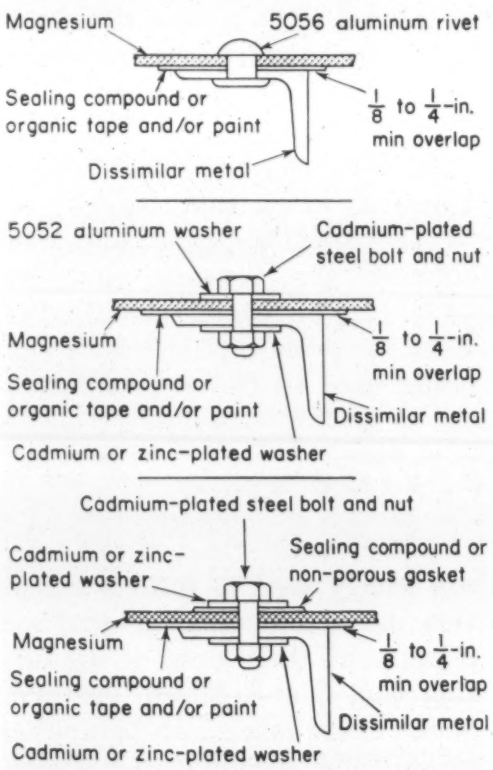


***Fig 3**—These diagrams show three ways to prevent corrosion when using magnesium with dissimilar metals or wood. In no case allow electrolyte to bridge over spacers.*

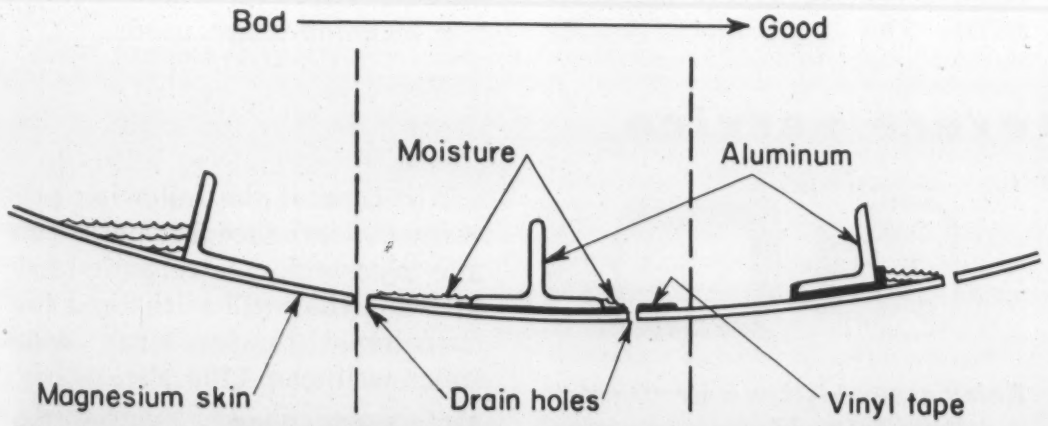


***Fig 4**—Provide drain holes for moisture, and use enough sealing tape so moisture does not bridge between magnesium and dissimilar metal.*

Transition Layer Is Key to Good

Ceramic-to-Metal Bonds

A quick summary of the four processes—their advantages and limitations—most commonly used in metallizing ceramics.

by G. R. Van Houten, *P. R. Mallory & Co., Inc.*

■ Structural and electronic devices frequently require the combined use of ceramics and metals, and in many of these applications hermetic (airtight) ceramic-to-ceramic and ceramic-to-metal seals are used. A major problem in joining metals to ceramics is finding bonding materials that will wet ceramic surfaces thoroughly, and bonding is usually accomplished by applying a thin intermediate coating that will adhere to the ceramic. If this transition layer is not readily wet by normal bonding metals, additional coatings are applied until a suitable outer layer is achieved.

Types of transition layers

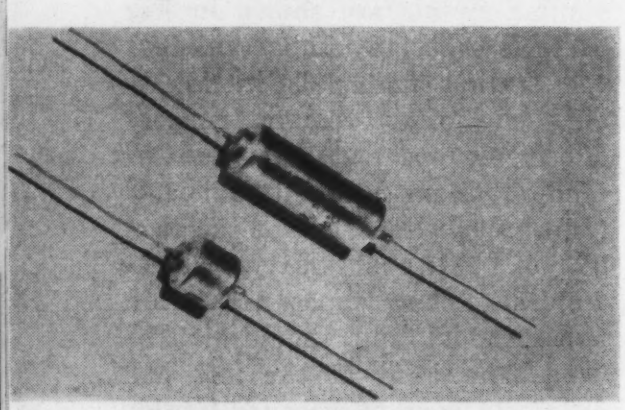
The transition layer or layers between the ceramic and the metal may be one of several types. With the oxide-type ceramics generally used in the electronics industry, most transition layers for high temperature seals use metal oxides which adhere to the ceramic body and are readily wet either by the parent metal or by other metals. The metal oxides may be a single oxide, as in the case of many glass-to-tungsten seals (the transition layer is primarily tungsten oxide), or they may be more complex, such as the spinel-type mixture of oxides usually found when alumina is coated with moly-manganese.

Transition layers can be formed by:

1. Applying oxide, metal or oxide-metal mixtures by vacuum evaporation, painting, dipping, spraying, flame spraying or electrodeposition, followed by firing in a suitable atmosphere.
2. Partially or completely oxidizing a metal layer that has been placed on the ceramic surface.
3. Partially or completely reducing a ceramic oxide to the metallic state on a ceramic surface.

The specific transition layer selected depends on the ceramic composition and the performance requirements.

for ordinary service . . .

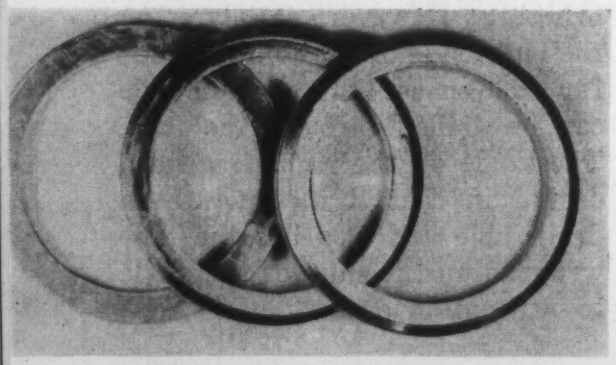


Sealed capacitors *suitable for low temperatures.*

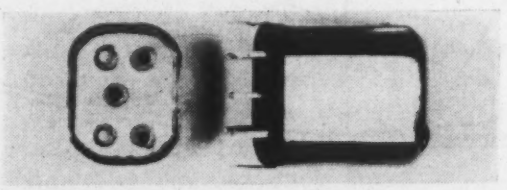
Silver paint-glass frit mixes are widely used to form a transition layer on ceramic surfaces because of their ease of application and standardized performance. These mixes can be applied by painting, including silk screening, then firing. The silvered surface can be either soldered or dip coated with solder.

Use of silver-glass mixes as ceramic coating agents often restricts the temperature range available for brazing or soldering steps so severely that the finished unit is unsuited for anything except low temperature operation. Problems associated with silver migration under applied voltages at elevated temperatures may also restrict the useful temperature. Therefore, if a high operating temperature or continuing high vacuum at an elevated temperature is required, other metallizing techniques are used.

. . . and for severe service



Aluminum oxide rings *metallized by moly-manganese process, then copper and nickel-plated, will be copper brazed to metal switch.*



Relay assembly *has a steatite plate metallized by moly-manganese process and solder coated.*

All three of the following processes can produce hermetic ceramic-to-ceramic or ceramic-to-metal seals that will withstand high operational temperatures, sometimes well over 1100 F.

Moly-manganese

The moly-manganese technique

consists of forming a thin metallic layer on a ceramic surface by applying a mixture of molybdenum and manganese powders and heating in a reducing atmosphere. (This method evolved from the tungsten-to-glass seal of the early 1900's. Vatter and Pulfrich developed a molybdenum-iron seal in Germany during World War II, and Nolte and Spurek substituted manganese powder for the iron powder and developed the final technique for the current moly-manganese bonding process.)

The initial step in applying a moly-manganese transition layer is the mixing of molybdenum and manganese powders, preferably of 5μ average particle size and 99+% purity, in a binder that will hold the powder on the ceramic surface. A typical binder is methyl methacrylate, although glyptal or cellulose nitrate might be used.

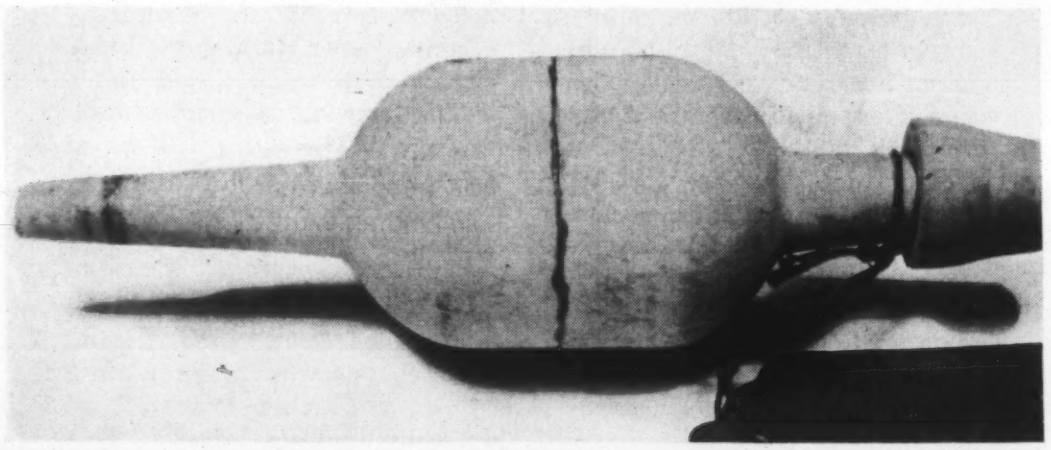
After the molybdenum-manganese mixture is painted onto the ceramic surface, the body is placed in a hydrogen or dissociated ammonia atmosphere at a temperature of 2375 to 2425 F, held at temperature for 5 to 20 min, and cooled to near room temperature before removal from the reducing atmosphere. The part is then plated with sufficient copper, nickel, or copper and nickel so that the molten braze metal in the subsequent brazing operation will not dissolve away too much of the transition layer and thus reduce joint strength and integrity. If necessary, the electrodeposited coatings may be refired in a reducing atmosphere to achieve limited diffusion and thus improve bonding at the plate interface.

This process is relatively insensitive to minor process variables and is therefore very well suited to quantity production. However, it has the disadvantage that multiple firings are required, at least one of them at a high temperature in a hydrogen atmosphere. Such firing may result in discoloration of some ceramics and damage to their electrical properties.

COMMON MATERIALS USED FOR METAL-CERAMIC STRUCTURES[a]

	Ordinary Service	Severe Service[b]
Metals	Copper, nickel	Inconel, molybdenum, nickel, stainless steel, tungsten
Ceramics and Glasses	Soft glasses, boron glasses	Alumina, mullite, steatite, forsterite
Transition Layer Materials	Silver-glass frit	Moly-manganese plated with copper and/or nickel, copper-26% titanium, copper-45% zirconium
Braze Filler Metals	Silver solders, lead solders, tin solders	Copper, copper-8% nickel, copper-26% titanium, copper-45% zirconium

[a]Expansion coefficients of materials listed vary widely; in many of the ceramic materials, the coefficients vary with slight changes in composition. Therefore, it is advisable to check experimentally the manufacturer's listed values before the material is used in an assembly.
[b]For joints requiring maximum integrity with minimum outgassing or vaporization of construction materials. Example: evacuated hermetically sealed electronic devices for service at 1475 F.



Moly-manganese joint *between two mullite tubes was made by an untrained engineer on his first attempt, indicating the relative insensitivity of this process. Helium leak rate of the joint, as measured by a mass spectrometer, was 16 cu cm per 100 years. The same engineer made numerous attempts with the hydride and active metals process before obtaining acceptable joints.*

Metal hydride

In the hydride process the work surface is coated with titanium hydride, alone or with copper powder, and fired at 1650 F to form a metallic transition layer.

The initial step in producing a metal hydride transition layer is the preparation of the powder mixture of copper and titanium hydride, preferably finer than 7μ avg particle size, in proportions to yield the copper-titanium eutectic (74% copper and 26% titanium by weight). This mixture is applied in a suitable binder which will hold the powder on the ceramic surface during the prefusion steps of processing. A number of materials have been prescribed: nitrocellulose or methyl methacrylate appear quite suitable. The coated part is fired in vacuum at 1650 F and cooled in vacuum. Final stages of cooling can be accelerated by introducing a non-oxidizing gas into the vacuum chamber.

Usually the hydride process metallizing and joining are done in a single step. When two ce-

Typical Uses

Typical applications of ceramic-metal combinations are ceramic and cermet cutting tools, high temperature compressor blades, nozzles and valve seats, hermetically sealed switches, relays and ceramic electron tubes.

ramic surfaces are to be joined, each of the joint surfaces is painted with the brazing powder. The parts are pressed together, jigged into place, and fired and joined together in a single furnacing.

The hydride process exhibits extremely high solder fluidity at the alloying temperature and therefore requires careful coating of the ceramic surface in order to insure a layer of uniform thickness. Even with care, it is extremely difficult to control the final physical dimensions of the braze area. However, the hydride process yields a strong bond, requires a firing temperature which is well below the sofening point of most ceramic bodies, and requires only a single operation in which the bonding layer is applied and the ceramic is joined to the other ceramic or metal surface.

The hydride process also permits brazing in vacuum or in inert atmospheres, avoiding possible hydrogen damage to the ceramic. Since titanium hydride bonds may be brazed in vacuum, better outgassing can be achieved; and as a result even high-chromium alloys can be readily brazed without oxidation.

Active metals

In 1948, Pearsall and Zingeser suggested that prealloyed active metal brazes might wet ceramics satisfactorily. This method compares with the "in situ" formation of the alloy by the hydride process, and led to the active metals bonding techniques. It differs from the hydride process only in the initial materials used.

Active metal seals may be applied using preform sheet or a powder in a binder such as nitrocellulose or methyl methacrylate. Typical procedures require the use of the eutectic alloy of titanium and copper. After the preform is placed in position or the powder is painted on, the process (i.e., vacuum firing) is substantially the same as that used in the hydride metallizing process.

The active metals process yields very high solder fluidity, making solder flow difficult to limit and control. Therefore, capillarity considerations control the allowable design. Advantages of the active metal process are strong bond, good reproducibility and extreme simplicity.

Materials Determine Design

Proper choice of materials and correct design are required if metals and ceramics are to be satisfactorily combined into a single structure. Metal-ceramic joints are relatively easy to design if expansion coefficients are properly matched, the lifetime temperature range is extremely narrow, and one phase is sufficiently plastic or a suitable ductile buffer layer is interposed. An example of the latter technique is the use of a tungsten-copper - nickel layer between nickel-bonded titanium carbide and Inconel. The tungsten alloy has the same expansion coefficient as the cermet and is sufficiently ductile to absorb the strain imposed by greater expansion of the Inconel.

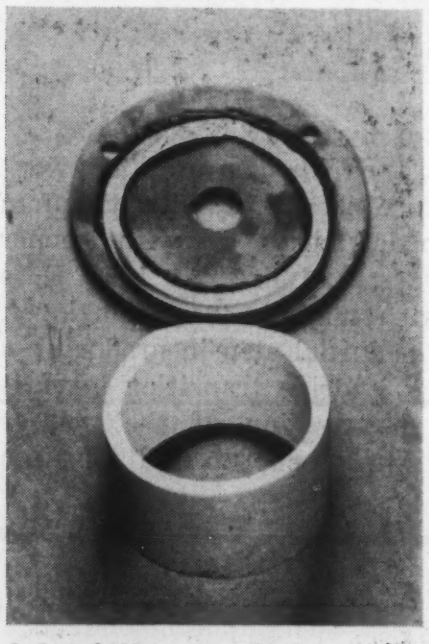
Metal vs ceramic joints

In metal-ceramic structures, metals are usually joined to metals by lap or scarf joints. The primary advantage of a lap over a butt joint is that the joint is in shear and the load is quite uniformly distributed over a large area. In a heavily loaded metal-to-metal butt joint, misalignment causes localized high stresses in some areas which may fail, thus increasing the load on the remaining joint area and causing catastrophic failure.

Ceramics are usually joined to ceramics with butt joints. Catastrophic failure of a butt joint in a ceramic body is not usually a factor because the brittle nature of the material requires the design of joints in which the stress levels are not high enough to cause failure of a ceramic joint.

Assemblies

Metal-ceramic assemblies may require several metal-to-metal, metal-to-ceramic or ceramic-to-ceramic joints. If a single braze or solder were used, all joints would have to be made simultaneously, and the problems of jigging and fixturing would be complicated; inadequately jigged parts tend to fall apart or shift out of alignment during joining operations. To overcome these difficulties, complicated assemblies are usually made with a series of brazing materials of different melting points. This practice permits each joining operation to be made at a lower temperature than the preceding one.



Joint failure *resulted from use of materials having widely different coefficients of expansion in the range 0 to 1300 F. Plate was steatite (5.5 x 10^{-6}); tube was mullite (2.8 x 10^{-6}).*

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16 AWARDS

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Materials in Design Engineering

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Materials in Design Engineering is proud to announce that it will again sponsor the Awards Competition for Best Use of Materials in Product Design. The entries in this 3rd Annual Competition will be reviewed by a distinguished board of judges.

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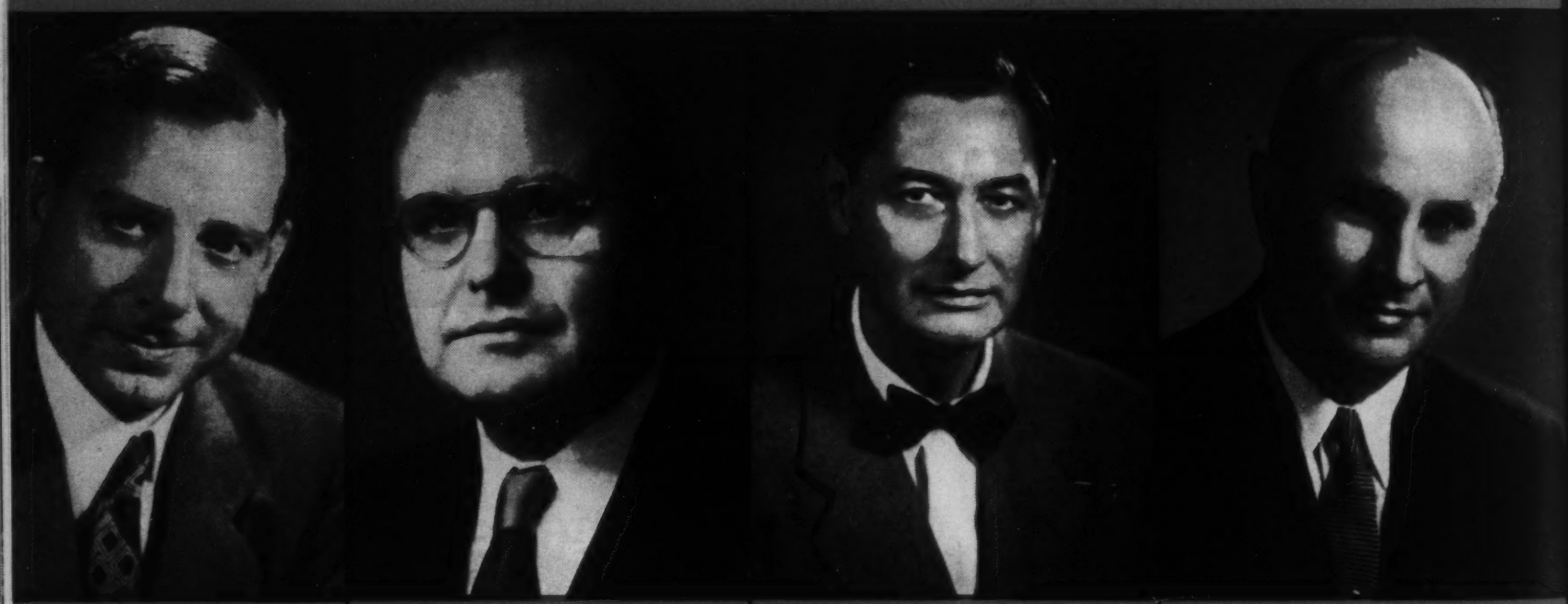

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Any person(s) or organization in the product manufacturing industries, or consultant(s) serving these industries, may submit an entry or entries. No one employed by a materials producer or supplier is eligible.

Simply select your best work of 1958

You can enter any product which you designed or redesigned, provided that 1) the design was completed during 1958, or 2) the product went into production during 1958. An entry may be either a new product or a redesigned product that demonstrates sound, imaginative and progressive use of engineering materials. Engineering materials are defined as metals, nonmetallics, finishes and coatings, and material forms (such as castings, forgings, moldings, etc.). The product may be a complete assembly, a subassembly, a single part or a component.

It's easy to prepare an entry

You need not write up your entry in the form of an article. Entries will not be judged for literary quality. See back page of this folder for details on the information that must be submitted with each entry.

Send in your entry by February 2

Entries must be mailed no later than February 2, 1959. Mail all entries to

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The award-winning entries will be published in the May Design Engineering Show issue of Materials in Design Engineering. Other entries not winning awards may be published at the discretion of the editors. Non-winning published entries will be paid for at the usual rate.

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Materials in Design Engineering

1958-59 AWARDS COMPETITION

for the Best Use of Materials in Product Design

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IMPORTANT: OBSERVE THESE SIMPLE RULES CAREFULLY!

Preparation of Entries

1. The following information must be provided with each entry in order to allow the judges to make competent decisions:

a. A detailed description of the product including photographs or drawings. If the entry is a redesign, provide before and after illustrations if possible.

b. A description of requirements in service and/or fabrication that must be met by the product and the material.

c. A description of the previously used materials (if entry is a redesign).

d. A description of the material or materials selected for the product entry.

e. An explanation of why the material or materials were selected for the product. Describe the advantages or benefits gained through the choice. Back them up with evidence — facts, data, charts, tables on performance, quality or cost.

In general, entries should show that the materials selected for the product —

Resulted in improved performance and/or lower costs or

Best met the design and service requirements.

Here are a few specific ways in which a product can benefit from intelligent materials selection:

- Long service life
- Lower basic materials cost
- Less material required
- Improved appearance
- Permitted a new design
- Reduced production costs
- Improved service performance
- Reduced scrap
- Reduced or eliminated maintenance
- Permitted lower cost design
- Allowed greater design flexibility
- Simplified production and fabrication

Remember! The more detailed and documented your entry is, the more consideration it will receive from the judges.

2. Entries or portions of entries will not be returned unless requested. Entries should not include valuable papers or other material which must be returned, because there is always some danger of loss or mutilation. Whenever possible, photostats, photographs or other copies of such materials should be used instead.

3. All entries must be postmarked not later than **February 2, 1959.**

Materials in Design Engineering plans to publish articles on the winning entries and reserves the right to publish articles based on entries not winning awards. The judges reserve the right to withhold awards at their discretion.

NOTE: Please observe the rules given above. Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

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Name _____ Title _____

Name(s) of person(s), group or organization who would receive award

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Company _____

Street address _____ City _____ State _____

Name or brief description of product being entered

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Was design (or redesign) of entry either completed or placed in production during 1958?

Does your employer consent to entry under terms of this competition?

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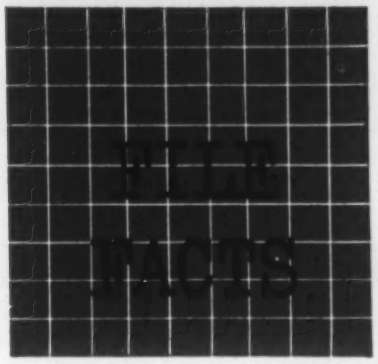

Comparative Properties of Hard Surfacing Alloys[a]

Alloy ↓	Hardness	Resistance to General Atmospheric Corrosion	Resistance to Hot Deformation	Resistance to Earth Abrasion	Performance Under Heavy Abrasion	Performance Under Sliding and Rolling Wear
HARDENABLE STEELS						
Carbon Steels						
Low	10	10	10	10	10	20
Medium	10-40	10	10	10	10	50
High	20-60	10	10	20	10	50
Low Alloy Steels						
Low Carbon	10	10	10	10	10	30
Medium Carbon	20-40	10	10	10	20	50
High Carbon	20-60	10	20	20	20	50
Medium Alloy Steels						
Medium Carbon	20-40	20	30	20	50	60
High Carbon	30-50	20	50	40	80	60
Medium-to-High Alloy Steels						
Low Carbon	20-40	20-50	40	20	30	40
Medium Carbon	30-60	20-30	50	40	70	60
High Carbon	40-80	20-30	50	60	80	40
High Speed Steel	80	20	70	40	40	40
AUSTENITIC STEELS						
Chromium-Nickel						
Low Carbon	30	90-100	20	20	30	30
High Carbon, Low Nickel	40	90-100	40	20	50	30
High Carbon, High Nickel	40	90-100	40	30	50	30
High Manganese	40	50	20	20	80	50
IRONS (not usually heat treated)						
High-Chromium Iron	60	60-80	80	70	80	80
High-Alloy Iron						
1.7% Carbon	70	60-80	60	60	70	70
2.5% Carbon	70	60-80	60	70	60	80-90
Very High Alloy	80	60-80	60	80	50	90-100
CAST IRONS (heat treated)						
Low Alloy	20-60	10	20	40	20	40
Medium Alloy	30-70	20	60	50	50	40
Medium-to-High Alloy	40-80	20-30	50	70	50	40
COBALT-BASE ALLOYS						
Low Alloy	40	90-100	100	50	80	90-100
High Alloy	70	90-100	100	70	60	100
CARBIDES						
Inserts	100	60-80	100	100	50	100
Composites	75-100	30-60	—	100	70	—
Powder	—	—	—	100	70	—
COPPER-BASE ALLOYS						
Copper-Zinc	20	60-80	10	20	10	80-100
Copper-Silicon	25	60-80	10	20	10	50-70
Copper-Aluminum	25-40	60-80	10	30	10	70-90
NICKEL-BASE ALLOYS						
Nickel-Copper[b]	20	80-100	10	20	20	20
Nickel-Chromium[c]	30	80-100	70	40	40	60
Nickel-Chromium-Tungsten-Molybdenum[d]	50	90-100	90	50	60	80

[a]Ratings based on a scale of 10 (poorest) to 100 (best). The table is intended to provide a first approximation in selecting a hard facing material. In some applications the recommendations indicated may not provide the most satisfactory service. For example, the influence of chemical corrosion has not been mentioned and in some uses this factor may be important. However, in most applications the table offers a ready means of choosing an alloy that will probably give the best performance under given service conditions.

[b]Monel. [c]Nichrome. [d]Hastelloy.

Source: *Welding Handbook*, 3rd Ed., American Welding Society, '50.

◀ For more information, circle No. 483

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For more information, turn to Reader Service card, circle No. 413

Here are more details on the properties of a . . .

Tough, New Polycarbonate Molding Compound

■ Completion and startup of a semi-works plant for the production of Lexan polycarbonate resin has been announced by General Electric Co., Chemical & Metallurgical Div., Pittsfield, Mass. Cost of the resin will probably be around $2.50 per lb at initial production and from $1.00 to $1.30 per lb once production gets going.

Announced in the spring of 1957 (see MATERIALS & METHODS, June '57, p 159), Lexan molding compound is a transparent, light amber resin which has no odor or taste. It has been evaluated in more than 100 different applications, including electrical, electronic, aircraft, automobile and business machine parts.

Properties

An outstanding feature of this relatively new resin is its toughness. GE scientists and engineers say, "Walls of parts made from the resin are strong enough to withstand the repeated blows of a hammer."

The company has been studying and evaluating the properties of the resin for the last year. A summary of its findings:

1. Toughness—Notched Izod impact tests performed on molded Lexan samples show it has an impact strength of 12 ft-lb per in. at 77 F and 1.6 ft-lb per in. at –65 F.

2. Heat resistance—The material is said to have excellent resistance to thermal-oxidative de-

CHEMICAL RESISTANCE—POLYCARBONATE VS OTHER PLASTICS[a]

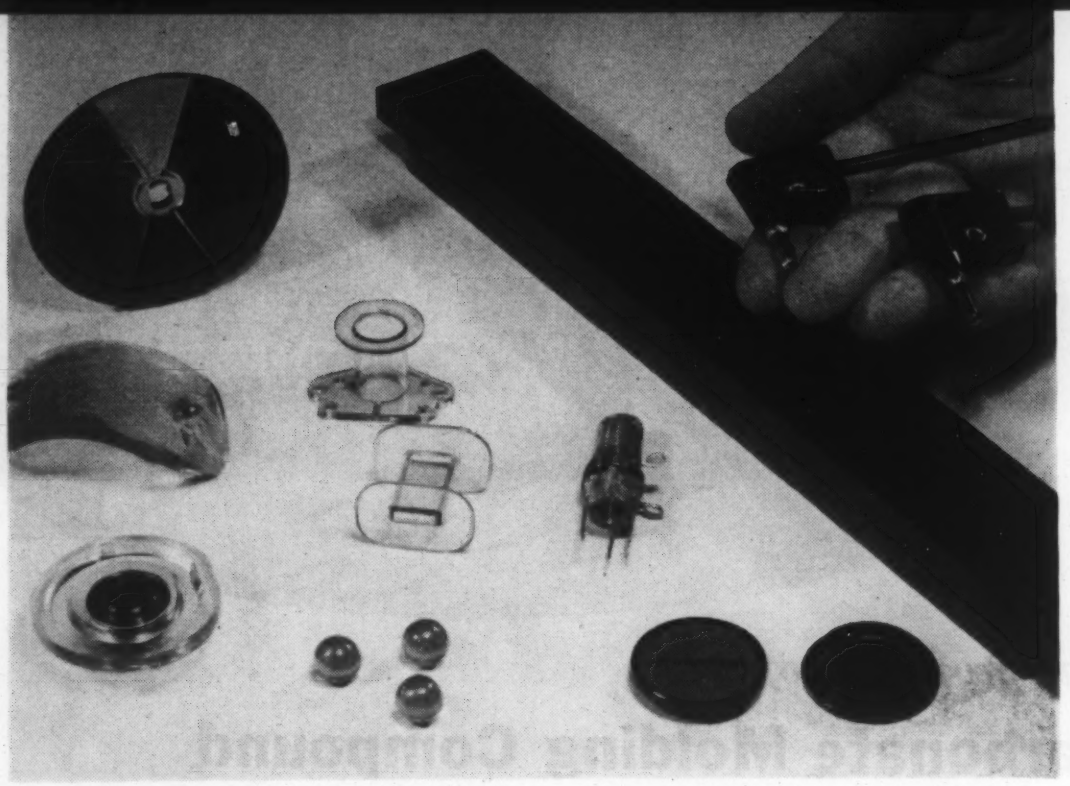
Chemical ↓	Polycarbonate	Polyamide	Acetal
Hydrochloric Acid (10%)	N	A	A
Sulfuric Acid (10%)	N	A	A
Nitric Acid (10%)	N	A	A
Phosphoric Acid (10%)	N	A	A
Ammonium Hydroxide (10%)	A	N	—
Sodium Hydroxide (10%)	A	N	A
Hydrogen Peroxide (3%)	—	A	—
Ozone (1%)	A	A	—
Acetone	PS	N	N
Benzene	PS	N	N
Carbon Tetrachloride	PS	N	N
Cresol	S	S	N
Ether	N	N	N
Hexane	N	N	N
Methyl Alcohol	N	N	N
Nitrobenzene	PS	N	N
Phenol (5%)	N	N	N
Gasoline	N	N	N

[a]Ratings are for service in fluid aged 1 mo at room temperature: N=no effect; PS=partly soluble; S=soluble; A=chemically attacked.

PROPERTIES OF PLASTICS COMPARED[a]

Type ➔	Polycarbonate	Polyamide	Acetal
PHYSICAL PROPERTIES			
Specific Gravity	1.20	1.14	1.43
Flammability, in./min.	Self-extinguishing	Self-extinguishing	1.1
Mold Shrinkage, in./in.	0.005-0.007	0.020	0.020
Clarity	Transparent	Translucent	Opaque
Water Absorption (24 hr), %	0.3	1.5	0.4
Coef of Ther Exp, per °F	45×10^{-5}	50×10^{-5}	40×10^{-5}
Ther Cond, Btu/hr/sq ft/°F/in.	0.121	0.145	0.140
Max Rec Svc Temp (continuous), F	250-275	250	185
MECHANICAL PROPERTIES			
Notched Izod Impact Strength, ft-lb/in.	14	1.5	2.0
Tensile Strength, 1000 psi	10	10	10
Tensile Modulus, psi x 10^3	320	310	—
Elongation, %	80	180	45
Flexural Strength, psi x 10^3	12	15	14
Flexural Modulus, psi x 10^3	375	310	410
Compressive Strength, psi x 10^3	11	13	—
Compressive Modulus, psi x 10^3	240	—	—
Heat Distortion Temperature (264 psi), F	285	150	212
Rockwell Hardness	R118	R113	R120
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm	2.1×10^{16}	4.5×10^{13}	6×10^{14}
Dielectric Constant (60 cps)	3.2	5.8	3.7
Dielectric Strength (⅛in.), v/mil	400	385	500
Power Factor (60 cps)	0.0009	0.05	0.004
Arc Resistance, sec	10.5	140	129

[a]Mfg. Chemists Assn., Feb '57.



Typical parts *made of polycarbonate resin.*

gradation at temperatures up to 300 F.

3. Weather resistance — One-year Florida exposure tests indicate weather has no effect on the tensile and compressive strength, and appearance of Lexan molded parts. GE scientists say weathering may start at 2 years except in highly strained parts.

4. Dimensional stability—Lexan molded parts show no dimensional change after aging 30 days at 160 F; 24 hr in water at room temperature; 4 days at 100% RH at 100 F; and 7 days in oil at 160 F. After aging 90 days at 257 F, molded parts showed a change in dimension of 1 mil per in.

5. Electrical properties—Power factor of Lexan is constant at 0.009 from room temperature to 212 F. Volume resistivity ranges from 2.1 x 10^{16} at 73 F to 2.5 x 10^{13} at 300 F. Dielectric constant ranges from 3.1 at –10 F to 3.2 at 212 F.

6. Creep characteristics—Tests show molded Lexan parts have good resistance to cold flow and good dimensional recovery. Under a load of 4000 psi a Lexan part had a deformation of 0.2% at 77 F and 0.3% at 158 F. Under a load of 2000 psi the part had a deformation of 0.1% at both 77 F and 158 F.

In another test, molded Lexan parts had an immediate recovery of 97% after being compressed for 2 to 3 min under an applied load of 250 lb at 75 F.

7. Chemical resistance — Lexan has good resistance to mineral and organic acids. It is insoluble in aliphatic hydrocarbons, ether and alcohols; partially soluble in aromatic hydrocarbons; soluble in chlorinated hydrocarbons. It is slowly decomposed by alkaline substances.

Conventional fabrication

Lexan resin is designed for injection molding in conventional equipment using standard molding techniques. It is supplied in the form of pellets approximately ⅛ in. in dia and ⅛ in. long and is packaged in 25-lb sealed containers. The resin must be kept clean and dry before molding to insure quality of the finished parts. Molding temperature of the resin is 525 to 625 F. High pressures are said to give best results; parts have been successfully molded at injection pressures of 10,000 to 30,000 psi.

According to the producer, Lexan resin can be molded in molds designed for nylon, acrylic, polystyrene, butyrate and other commonly used thermoplastic materials. However, it does have a high melting point (514 F) and flow characteristics are somewhat different from other plastics.

Cured polycarbonate resin parts can be drilled, tapped, threaded, sawed, turned, shaped, milled, punched, sheared, sanded, filed and buffed.

Air Hardening, High Strength Steel Is Easily Welded

■ A new ultra high strength alloy steel that can be air hardened and tempered to a tensile strength of 280,000 psi has been developed by U. S. Steel Corp. Called Airsteel X200 and available in the form of billets, blooms, bars, plate, strip and sheet, the new alloy is said to climax a two-year search for a steel that "would surmount many welding and fabricating problems and at the same time possess the desired strength and toughness required for missiles and space vehicles." In addition, the alloy stays strong up to 1200 F.

Air hardening an advantage

According to U.S. Steel, the development is especially significant because the alloy's ability to be air hardened eliminates the elaborate oil or salt quenching normally required for ultra high strength steels. To bring the alloy

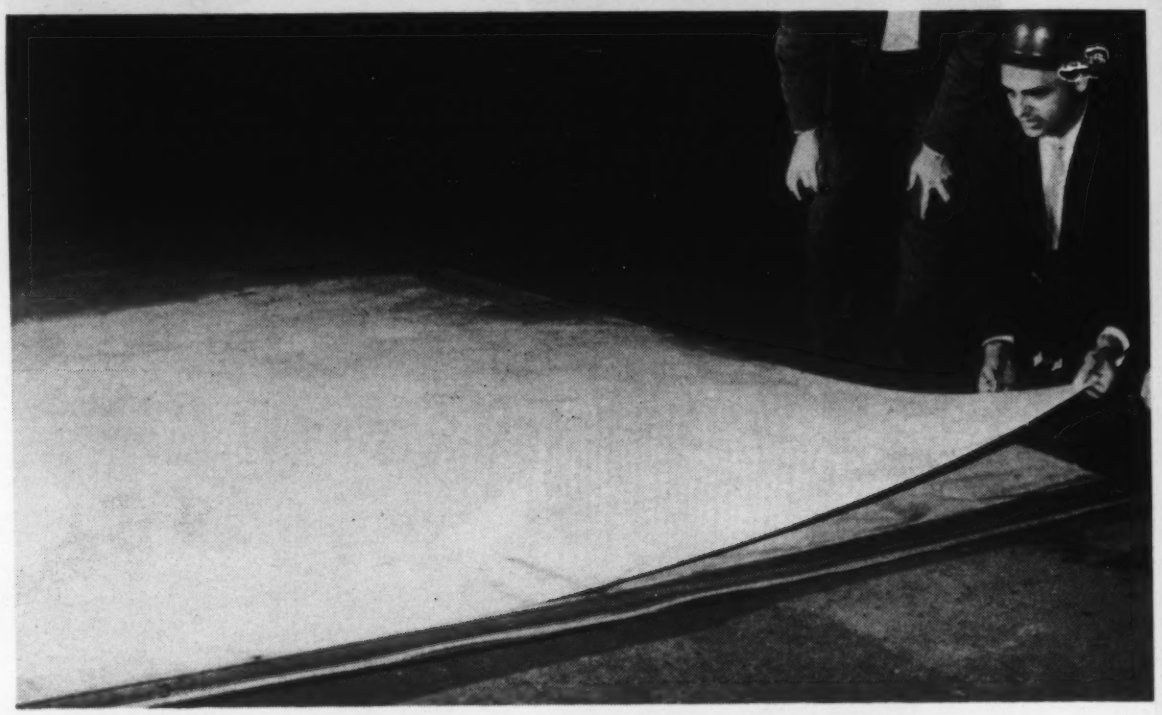
to full strength, it is air cooled from 1725 F ±25 F, tempered 30 min at 600-750 F, and air cooled.

The ultra high strength of the new steel is said to result from "a careful balancing of alloying elements (see composition table) which have proven suitable for rendering steel air hardenable." Of major importance is the fact that the tempering treatment imparts ductility and toughness (see property table), thus avoiding the problem of brittleness.

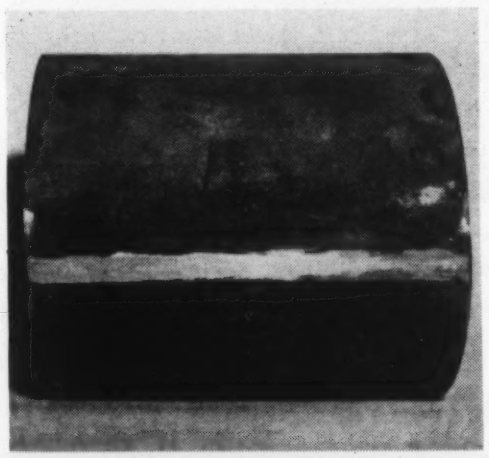
Fabricability

Both sheet and plate are supplied in the annealed or "soft" condition, permitting forming, cutting or shaping to be easily accomplished. The large sheets shown in the accompanying photo, for example, are said to be the widest ever produced by sandwich rolling. The 140-in. wide, 0.095-in. thick sheets were rolled from four X200 plates. Total variation in the gage of all four sheets is only 0.006 in. According to U.S. Steel, the great width makes it possible to reduce the overall weight of missiles or aircraft by eliminating many of the joints and seams necessary when using narrower sheets.

Exhaustive tests conducted by the Consolidated Western Steel Div. indicate that the new steel can be easily welded. According to U. S. Steel, both metallic and inert arc welding can be used.

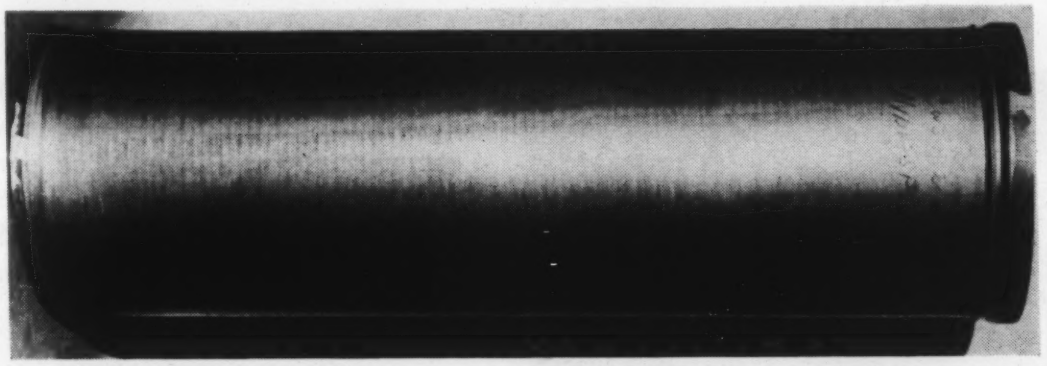


Greatest width *ever achieved is claimed for this sandwich rolled from Airsteel X200.*



Quarter-inch thick *welded cylinder (left) was hydrospun into . . .*

. . . 0.080-in. thick cylinder *(below). After heating, air hardening and tempering, the welded seam was found to be as strong as the metal itself—about 280,000 psi.*



PHYSICAL PROPERTIES OF X200

Density, lb/cu in.	0.280
Coef of Ther Exp (68-900 F), 10^{-6} per °F	7.5
Electrical Resistivity, microhm-cm (68 F)	
Annealed	38
Heat Treated	50
Modulus of Elasticity, 10^6 psi	30.2

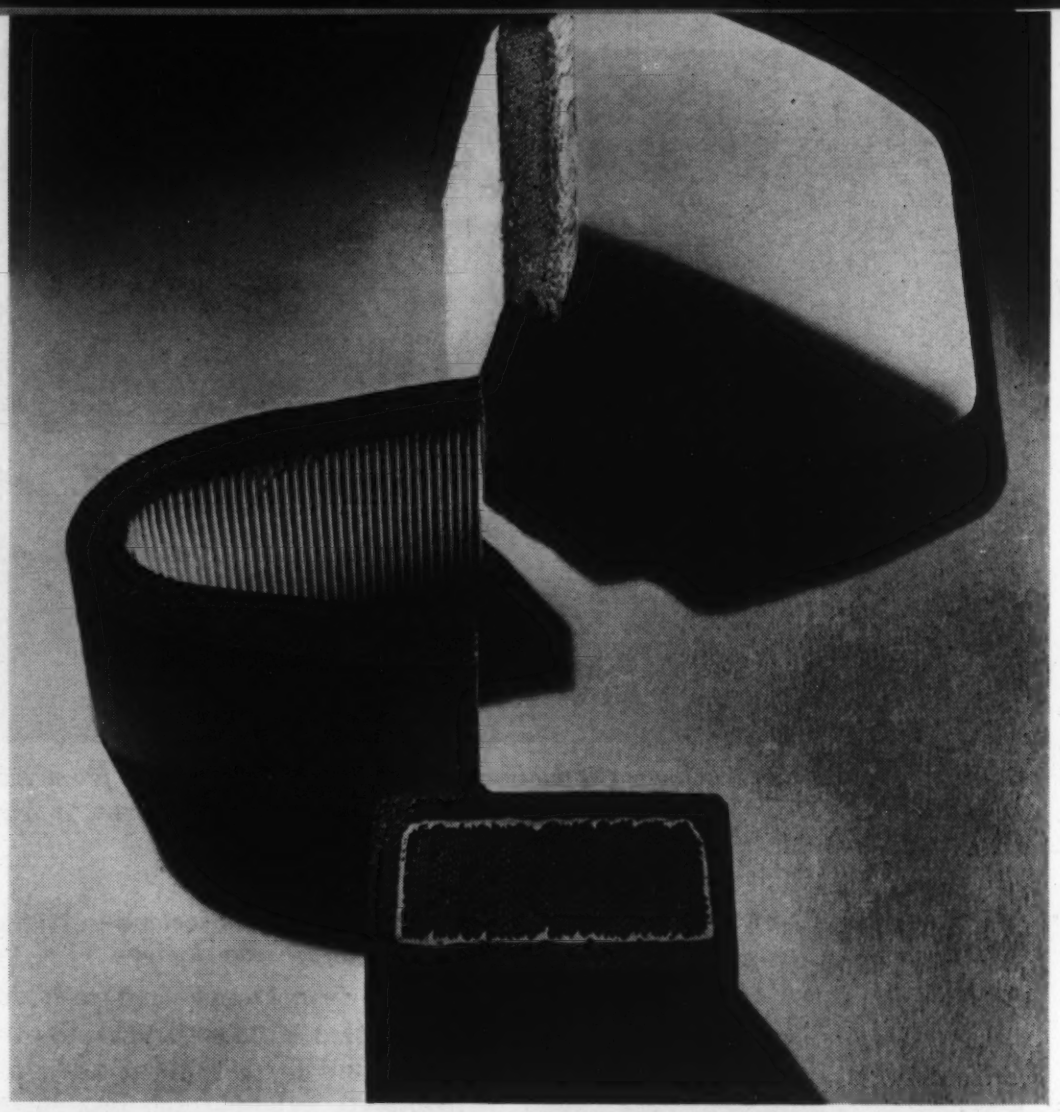
COMPOSITION OF X200, %

Carbon	0.41-0.46
Manganese	0.75-1.00
Phosphorus	0.025 max
Sulfur	0.025 max
Silicon	1.40-1.75
Chromium	1.90-2.25
Molybdenum	0.45-0.60
Vanadium	0.03-0.08

TENSILE PROPERTIES OF HEAT TREATED X200[a]

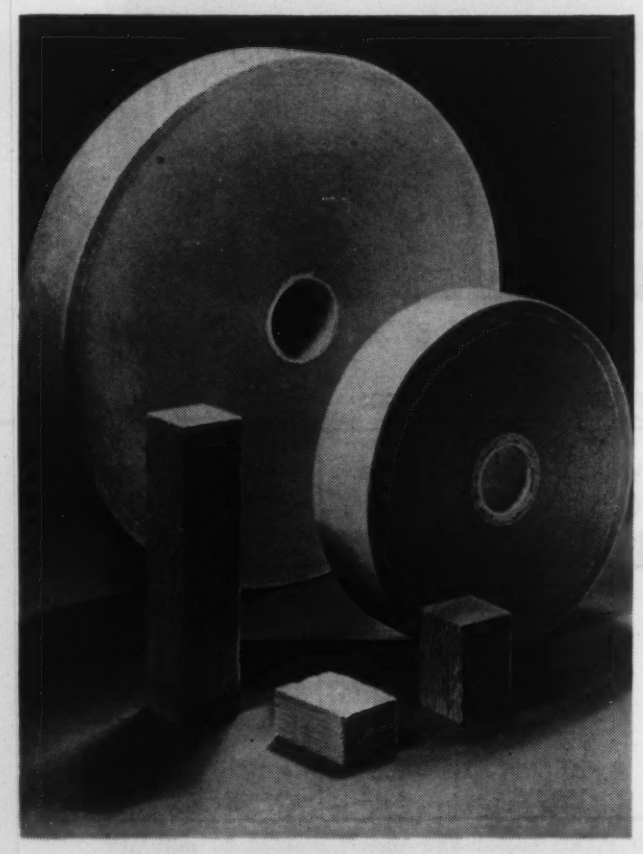
Tempering Temp, F	Rockwell Hardness	Yield Strength (0.2% offset), 1000 psi	Tensile Strength, 1000 psi	Elongation (in 2 in.), %
400	C55	214	313	9.0
500	C54	236	296	7.2
600	C54	238	291	6.8
700	C53	242	288	7.0
700[b]	C52	241	286	5.8
800	C52	225	270	10.0
1000	C48	201	238	7.2
1200	C40	159	181	11.5

[a]0.060-in. specimens austenitized 15 min at 1750 F, air cooled and then tempered 30 min at indicated temperature. All specimens longitudinally oriented except where otherwise indicated.
[b]Transverse orientation.



***Typical ceramic shapes** made by a new fabricating technique: wedge-shaped piece (top); U-shaped corrugated cellular structure (center); and block (bottom).*

Ceramic Honeycomb Structures for Continuous Use at 1300 F



***Two ceramic disks,** 20 and 10 in. in dia, are protected by a ceramic rim. Ceramic honeycomb blocks are also shown.*

■ Extremely thin-walled ceramic honeycomb structures are now commercially available. The porous structures are said to withstand temperatures up to 1800 F with virtually no thermal expansion. They can operate continuously at 1290 F.

Products of Corning Glass Works, Corning, N. Y., the structures have a low coefficient of thermal expansion (0.55 x 10^{-7} per °F) and can withstand extreme thermal shock. They can be made of any ceramic material, including Corning's high strength crystalline glass, Pyroceram. The shapes are made by a new process, details of which have not been revealed by the company. Disks 20 in. in dia and 3¾ in. thick have been made by the process.

A protective rim for such disks is formed by a special coating with matching thermal expansion and heat resistance. The rim can be applied to all sizes of the ceramic structures to protect the thin-edged walls against outside stresses. The rim can also be used as a mounting support.

Properties and uses

The structures, designated Cercor, have a compressive strength (parallel to the channels) of 2000 psi. They have a density of about 30 lb per cu ft and a specific heat of 0.20 Btu/lb/°F. Other properties are given in an accompanying table.

The low expansion at high temperatures and the high surface area of Cercor structures make them potentially useful as catalyst supports, gaseous heat exchangers, and high temperature structural materials. The new ceramic parts

MORE WHAT'S NEW IN MATERIALS

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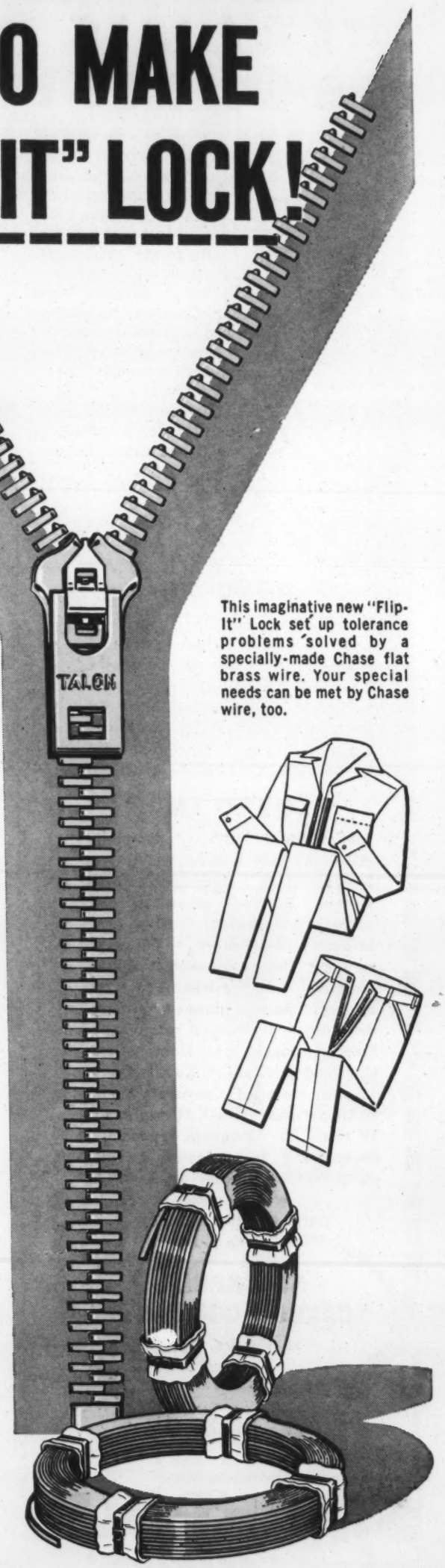
IT TAKES "MADE TO MEASURE" FLAT BRASS WIRE TO MAKE A NEW TALON "FLIP-IT" LOCK!

Talon, Incorporated finds Chase precision wire tolerances make new zipper for sports and work clothing possible

Heart of Talon Fastener's new Flat-Top Zipper is the imaginative new design of a "Flip-It" Lock. Its production depends on the economical mass output of several intricate, close-tolerance parts—slider body, spring and a special cam-action pull. So Talon asked Chase Brass & Copper Co. wire service to go to work on the production problem—involving prong length, spring fatigue, permanent set, and a critical edge tolerance.

Chase's answer was a flat brass wire with a perfect round edge, "made to measure" to meet Talon's specific needs. The finished fastener resists damage in laundering and pressing, stands up to the toughest wear conditions in work and sport clothes.

You, too, can have the assistance of the Chase Wire Service Man in meeting your application problems. Call your nearest Chase Representative, or write to Chase at Waterbury 20, Conn.



This imaginative new "Flip-It" Lock set up tolerance problems solved by a specially-made Chase flat brass wire. Your special needs can be met by Chase wire, too.

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY BRASS & COPPER

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Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York (Maspeth, L. I.) Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

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There's Engineering "Magic" in... CERAMIC MAGNETS!

You can do things with Stackpole Ceramagnet you can't do with conventional permanent magnets . . . and you can handle many ordinary magnet applications better . . . often at less cost. Ceramic magnets have highest magnetic permanency. No keepers needed. They are electrically nonconductive, weigh less . . . and offer numerous other advantages.

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Magnetic shafts • Grippers • Chucks
Couplings • Ion traps • Seals • Arc snuffers • Centering devices • TV yoke cores • TV "pin cushion" magnets • TV field equalizers • TV PM focusers • *and many other uses*

USED IN

Fuel pumps • Motors • Magnetic drives • Door latches • Clutches Speedometers • Switches • Toys Games • Statuette bases • Utensil racks • Novelties • Desk sets Relays • Generators • Oil level meters • Electric blankets • Butter warmers • Coffee makers • Can openers • Burglar alarms • Vending machines • Submerged gas pumps Pressure gauges • Float meters Lightning arresters • Key keepers Inverter motors • Conveyors • Pot holders • Magnetos • Microphones TV sets • Magnetic separators Recorders • Sonar devices • Gas pump starting switches *and hundreds of other things*

WRITE FOR ENGINEERING BULLETIN RC-11A

STACKPOLE CARBON COMPANY
St. Marys, Pa.

STACKPOLE *Ceramagnet*®

THE PERMANENT MAGNETS THAT ARE REALLY PERMANENT

For more information, circle No. 442

also have potential use as air preheaters and aftercoolers, and as burner plates and covers. (For information on other high surface area ceramic shapes, see M/DE, Oct '58, p 142.)

Dimensions

The structures have 20 holes per in. and a surface area of 1500 sq ft; of the total surface area, 75 to 80% is open space. Holes in Cercor pieces are approximately 0.095 in. long and 0.045 in. high. Average wall thickness of the honeycomb structures is 0.005 in. Maximum cell depth of the structures is presently 3½ in.

PROPERTIES OF CERCOR STRUCTURES

Melting Temperature, F	2280-2460
Coef of Ther Exp, per °F	0.55 x 10^{-7}
Max Operating Temp (no load), F	
Short Time	1830
Long Time	1290
Compressive Strength, psi	
Parallel to Cell	2000
Perpendicular to Cell (par. to flat rib)	400
Perpendicular to Cell (perp to flat rib)	40

Heat Resistant Epoxy Resins

■ A substantial increase in the heat resistance of epoxy resins is in the offing with the development of new epoxy resin-producing chemicals. Heat distortion temperatures of over 500 F accompanied by good aging characteristics at this temperature have been obtained with resins produced from the new materials.

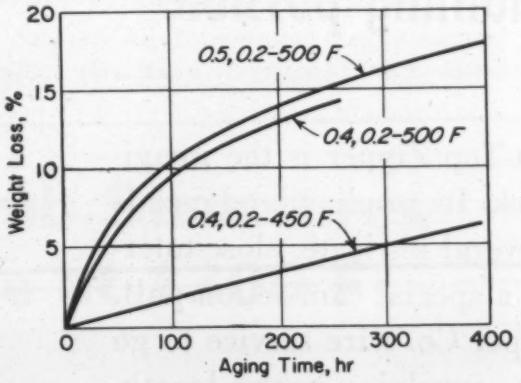

***Fig 1**—Relationship between aging time and weight loss at 450 and 500 F. Figures for each curve are maleic anhydride and trimethylolethane-hydroxyl equivalents per epoxide equivalent respectively.*

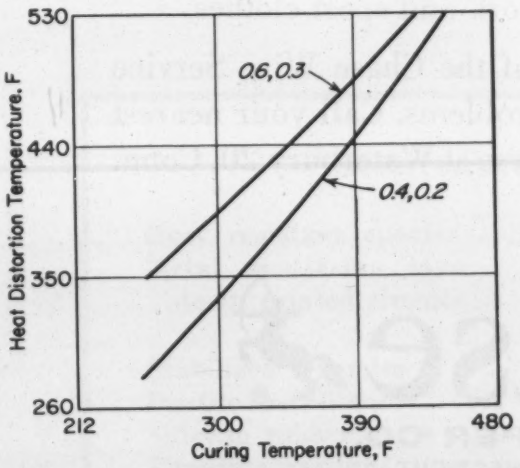

***Fig 2**—Cure temperature vs heat distortion temperature of cured unfilled epoxy resins. Figures for each curve are maleic anhydride and trimethylol - propane - hydroxyl equivalents per epoxide equivalent respectively.*

Developed by Union Carbide Chemicals Co., Div. of Union Carbide Corp., 30 E. 43rd St., New York 17, the resins are currently available in development quantities.

Potential uses

Carbide says the epoxies look promising for laminating and casting resins, coatings, adhesives and foams.

Laminating and casting resins: One major benefit derived from the chemicals as laminating and casting resins as compared to conventional epoxies is high temperature stability. Typical properties of a glass laminate prepared with dicyclopentadiene dioxide resin are shown in the accompanying table. Results of aging tests on unreinforced resins are given in Fig 1.

Heat distortion temperatures (ASTM, 264 psi) after 400 hr aging at 450 F and even at 500 F were found to be above 575 F (maximum temperature of the testing device). The effect of curing temperature on heat distortion temperature of two resin formulations is given in Fig 2.

Other major benefits of laminating and casting resins prepared from Carbide's epoxies as compared with conventional epoxies are 1) easier handling, since the resins have lower viscosities, and 2) excellent color stability.

Coatings: Development work now

This article is adapted from McGary, C. W., Jr., and Patrick, C. T., Jr., "High Temperature Epoxy Resins," a paper delivered before the National Conference, American Chemical Society, Sept '58.

Enjay Butyl window-sealing tape was employed throughout the newly erected Industrial Reactor Laboratories in Plainsboro, N. J. Architect: Skidmore, Owings & Merrill

ENJAY BUTYL

caulking prevents leakage in new Atomic Reactor Lab

Butyl caulking tape permanently seals joints and copings against leakage in this new Atomic Reactor Lab. Tough, weather-resistant Butyl helps provide long-lasting protection against all climatic conditions. Enjay Butyl was chosen to do this job because of its inherent resistance to sunlight, ozone, moisture, aging and vibration.

Architects and design engineers are constantly finding new ways to use Enjay Butyl in building and construction. Its many outstanding qualities —plus its low cost—make it perfect for use in a wide variety of applications. Call or write our nearest office today for a complete list of suppliers.

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Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

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the
glamorous finish of
Calcinator home incinerator
is

Sicon®

Silicone heat resistant finish
for LONG LIFE PRODUCT APPEAL

Retains
Rich Colors
at 425°F.
with excellent adhesion
and mar resistance

Sicon, the first high temperature finish to break the "heat barrier" in colors, is specified for all Calcinator home incinerators. A wide range of colors is employed: Metallic Blue, Coppertone and Taupe, as shown above; also Yellow and Turquoise. These smart Sicon enamels lend compelling eye-appeal on the sales floor. Equally important, their ability to retain their rich colors and gloss in every day service—exposed to temperatures in the 425°F. range—has helped produce thousands of satisfied Calcinator users. Sicon is easy to apply by brush, spray or dip. At Calcinator it is hand sprayed and baked by gas-fired ovens for 20 minutes at 425°F.

Sicon's excellent adhesion and film stability has led to its use on scores of applications, of widely varying heat resistance requirements up to 1000°F. Midland engineers will be glad to analyze your problem and suggest a formula. Send us all details.

Write for Literature
Dept. L-1

MIDLAND Industrial Finishes Co.
Waukegan, Ill.

ENAMELS SYNTHETICS LACQUERS
VARNISHES

Sicon

PROPERTIES OF GLASS LAMINATE[a]

Tensile Strength, psi	50,300
Tensile Modulus, psi	3.3 x 10^6
Compressive Strength (edgewise), psi	62,700
Compressive Modulus, psi	4.1 x 10^6
Flexural Strength, psi	
Room Temp	74,700
300 F	66,400
400 F	67,800
500 F	47,100

[a]Resin was prepared from 0.5 maleic anhydride equivalent and 0.33 glycerol-hydroxyl equivalent per epoxide equivalent and cured 1 hr at 325 F and 6 hr at 400 F.

going on with one of the epoxies (Epoxide-201) indicates that coatings with excellent adhesion and color stability can be made. Conventional epoxy coatings based on bisphenol-A have enjoyed a rapid growth; however, their color instability has prevented their expansion into many markets. Carbide feels their new epoxies will contribute to the growth of epoxy resins by filling the needs of coating applications which presently cannot be met with conventional epoxy coatings. Fast acid reactivity suggests the use of these products to improve alkyd and acrylic coatings by crosslinking.

Adhesives and foams: According to the developer, the epoxies are too new to be completely evaluated as adhesives and foams. They seem to be quite promising for high temperature structural adhesives for use in aircraft and missiles. The good thermal stability seems beneficial for foam structures; however, no development work has yet been done in this area.

Three new chemicals

Carbide's three new epoxy resin-producing chemicals are:

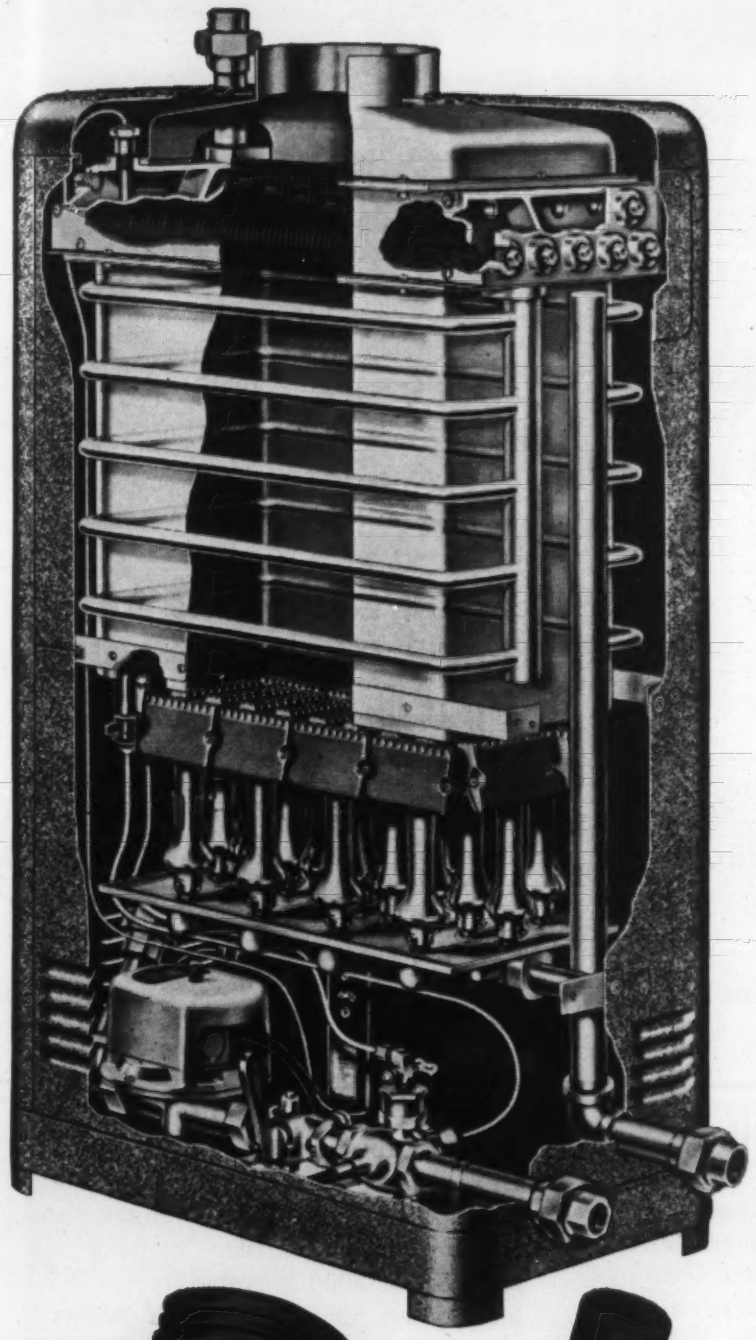
1. Epoxide 201: A low viscosity liquid at room temperature. Most of UCC's development work has been on this material.

2. Dicyclopentadiene dioxide: A crystalline solid at room temperature. When mixed with a curing agent and heated slightly the material forms a stable, low viscosity fluid system. It will cure rapidly when further heat is applied.

3. Vinylcyclohexene dioxide: This material can be used as a chemical intermediate or as a reactive diluent for other epoxy resins. It can be used to reduce viscosity of an epoxy

For more information, turn to Reader Service card, circle No. 463

Hot water always on tap



WOLVERINE TRUFIN
TYPE H/A

WOLVERINE TRUFIN
TYPE H/R

TRUFIN TYPE H/R is used in the Ruud unit above because of its tremendous heat absorbing capacity.

Ruud Engineers Say

WOLVERINE TRUFIN® HAS "NINE TIMES THE CAPACITY"

In its nearly 70 years as a leading manufacturer of water heaters, Ruud Manufacturing Company of Kalamazoo, Michigan has established an enviable reputation for the outstanding efficiency and quality of its products.

Contributing in a high degree to this efficiency and quality is Ruud's use of Wolverine Trufin — the integrally finned heat exchanger tube manufactured by Wolverine Tube.

Because of its great heat transfer capabilities Ruud uses high finned Trufin H/A and H/R as the heat exchangers of its water heaters. In describing these exchangers, Ruud engineers say **"The heat exchangers consist of copper fin tubes (Wolverine Trufin) having nine times the heat absorbing capacity of plain tubing of like diameter."**

Trufin's tremendous capacity to transfer more BTU's per foot of tube also helps Ruud design units that are extremely compact —requires only 3½ square feet of floor space. And because Trufin's fins are actually an integral part of the tube wall, they can never shake loose under the stresses of the temperatures and vibrations encountered in water heaters.

Wolverine Trufin is the original integrally finned heat exchanger tube. It is available in a wide range of alloys, types and sizes. If your product or manufacturing process calls for finned tube don't settle for substitutes. Like Ruud, specify Wolverine Trufin. For complete information write for your copy of the Trufin Catalog.

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

See Wolverine's exhibit at the 14th International Heating and Air Conditioning Exposition, Philadelphia, Pa. January 26-29.

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SALES OFFICES IN PRINCIPAL CITIES
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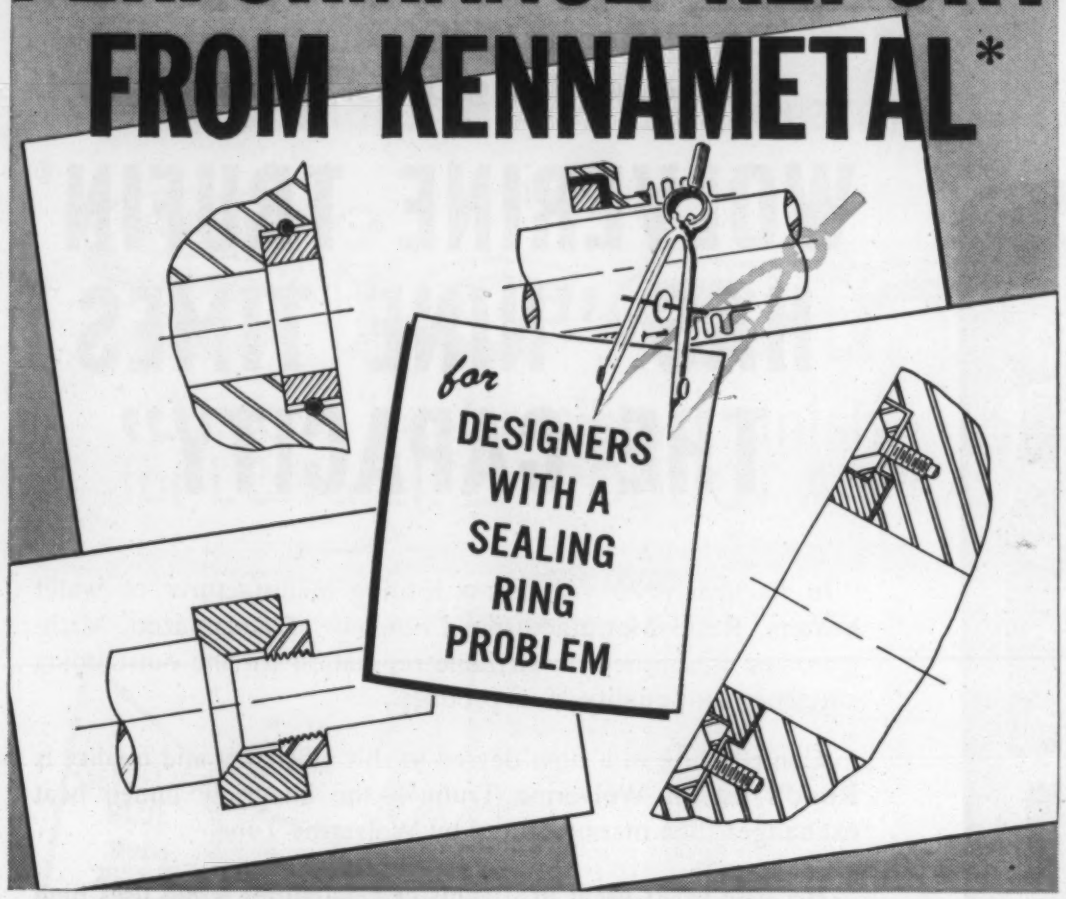
PERFORMANCE REPORT FROM KENNAMETAL*



If you have any sealing ring problem that demands . . .

1. Extreme resistance to abrasion, or

2. The ability to resist elevated temperatures, or

3. Unusual resistance to severe corrosion.

KENNAMETAL has some proven answers for you.

ABRASION RESISTANCE. Kennametal tungsten carbide sealing rings installed in a deep-well rotary pump gave one to two years' service; packing type seals had failed in two to four weeks. Kennametal rings in a recirculating pump, handling water with fine grains of iron oxide, lasted 30 to 60 *days*. Packing type seals failed in 24 to 48 *hours*.

ELEVATED TEMPERATURES. A jet engine shaft seal of Kentanium,* a titanium carbide, operating without lubrication at 15,000 surface feet per minute under 0.3 to 0.6 lbs. pressure per lineal inch of circumference and 900° to 1000° F, outperformed every other material. Kentanium Rings are stress-free—do not tend to split radially, maintain original face flatness even at high temperatures, and have exceptional wear and resistance strength.

SEVERE CORROSION. Where corrosion and abrasion are present, Kennametal has seal rings of Grade K501, a platinum-bonded carbide. Used as seals to confine liquid oxygen or fuming nitric acid, sealing results are reported as "far superior to any previously used materials, with no indication of face wear."

Other desirable characteristics of Kennametal seals: high modulus of elasticity, low expansion under heat, high resistance to wear and much lower service cost. For more information, ask for "Characteristics" book, write KENNAMETAL INC., Latrobe, Pennsylvania, Dept. MDE.

*Kennametal and Kentanium are the trademarks of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum. 3070

INDUSTRY AND
KENNAMETAL
. . . Partners in Progress

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resin without lowering the resin's temperature resistance.

An important feature of the new materials is their reactivity with dibasic acid and anhydride curing agents. Conventional epoxies (reaction products of epochlorhydrin and bisphenol-A) react more rapidly with amine curing agents. Benefits of dibasic acid or anhydride curing agents as compared with amine curing agents are: lower cost, lower toxicity and higher heat resistance.

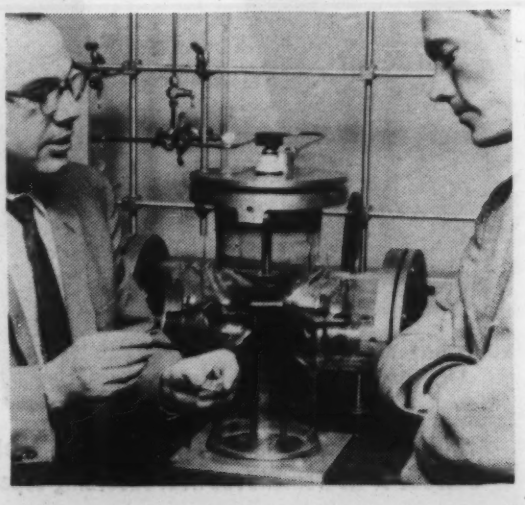
Metal Sputtering Lays Down Printed Circuits

Research in the field of cathode metal sputtering indicates that this century-old technique may be useful in producing precision printed circuits. It appears that entire circuits, including resistors, capacitors and leads, may be laid down by metal sputtering. This technique utilizes ionized gas molecules to bombard a cathode, dislodging atoms of metal which then redeposit on nearby surfaces.

Harold Basseches, of Bell Telephone Laboratories, has produced thin films of a number of high melting point metals. For example, tantalum and titanium, melting at 5400 F and 3000 F respectively, were laid down in films which showed resistivity sufficiently high for use in printed circuit resistors.

Some applications

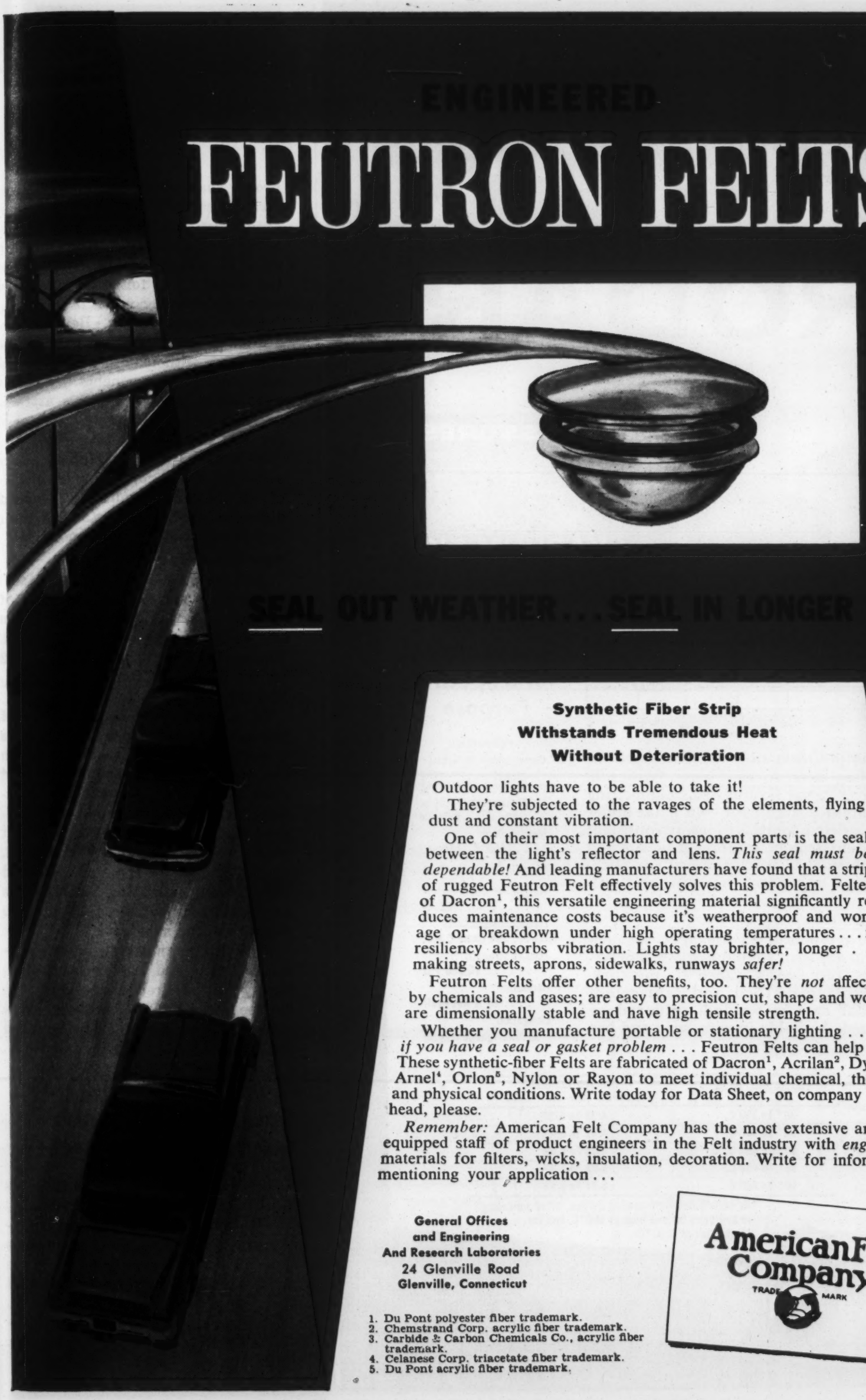
R. W. Berry, a colleague, has produced printed capacitors by a combination of sputtering and chemical methods. A tantalum film of the



Apparatus *used for cathode metal sputtering of printed circuits.*

ENGINEERED

FEUTRON FELTS



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Synthetic Fiber Strip
Withstands Tremendous Heat
Without Deterioration

Outdoor lights have to be able to take it!

They're subjected to the ravages of the elements, flying dust and constant vibration.

One of their most important component parts is the seal between the light's reflector and lens. *This seal must be dependable!* And leading manufacturers have found that a strip of rugged Feutron Felt effectively solves this problem. Felted of Dacron[1], this versatile engineering material significantly reduces maintenance costs because it's weatherproof and won't age or breakdown under high operating temperatures . . . its resiliency absorbs vibration. Lights stay brighter, longer . . . making streets, aprons, sidewalks, runways *safer!*

Feutron Felts offer other benefits, too. They're *not* affected by chemicals and gases; are easy to precision cut, shape and work; are dimensionally stable and have high tensile strength.

Whether you manufacture portable or stationary lighting . . . *or if you have a seal or gasket problem* . . . Feutron Felts can help you. These synthetic-fiber Felts are fabricated of Dacron[1], Acrilan[2], Dynel[3], Arnel[4], Orlon[5], Nylon or Rayon to meet individual chemical, thermal and physical conditions. Write today for Data Sheet, on company letterhead, please.

Remember: American Felt Company has the most extensive and best equipped staff of product engineers in the Felt industry with *engineered* materials for filters, wicks, insulation, decoration. Write for information, mentioning your application . . .

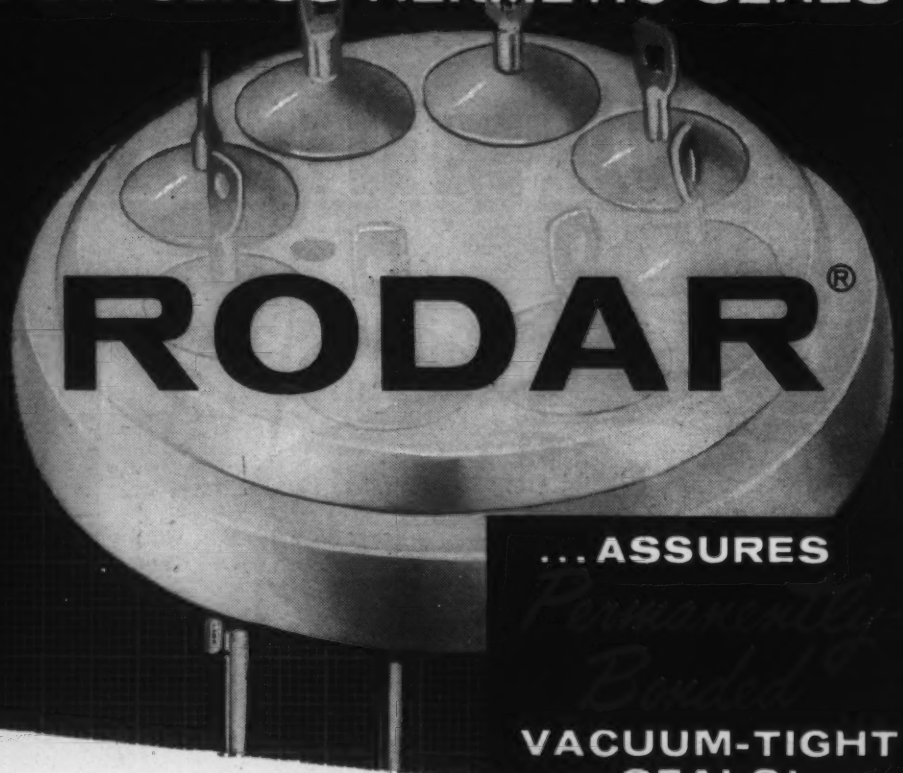
General Offices
and Engineering
And Research Laboratories
24 Glenville Road
Glenville, Connecticut

1. Du Pont polyester fiber trademark.
2. Chemstrand Corp. acrylic fiber trademark.
3. Carbide & Carbon Chemicals Co., acrylic fiber trademark.
4. Celanese Corp. triacetate fiber trademark.
5. Du Pont acrylic fiber trademark.

AmericanFelt Company
TRADE MARK

For more information, turn to Reader Service Card, circle No. 387

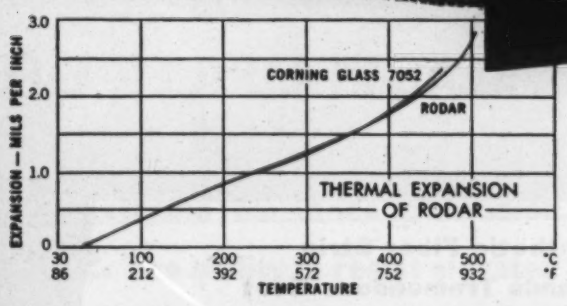
THE *Specialized* ALLOY
FOR GLASS HERMETIC SEALS



RODAR®

...ASSURES

VACUUM-TIGHT SEALS!



This precision alloy was developed for sealing metal to hard glass. Wilbur B. Driver Rodar is processed from melting to finished size in our own plant under the strictest controls to insure consistent analysis, temper, uniform grain size and conformance to customers' specifications. The superior stamping and sealing properties of Rodar make it *the preferred sealing alloy.*

Rodar produces a permanent, vacuum-tight seal with simple oxidation procedure and resists attack by mercury. Readily machined and fabricated, Rodar can be welded, soldered or brazed. Available in wire, strip and bar to your specifications.

Another Special Alloy for a Specific Purpose

PROPERTIES

Composition (Nominal)
Nickel 29%
Cobalt 17%
Manganese . . .30%
Iron . . . . . Balance

Melting Point
. . 1450°C. (Approx.)

Specific Gravity. . 8.36

Weight Per Cubic Inch
. . . . . .302 lb.

Electrical Resistivity
. . . 294 Ohms C.M.F.

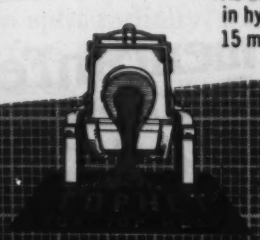
Tensile Strength
. . . . . 80,000 PSI

Hardness
. . . . 82 B Rockwell

Elongation
30% (2" gauge length)

Temperature Range	Average Thermal Expansion, *Cm/Cm/°Cx10-6
30° To 200 C.	4.33 To 5.30
30° To 300 C.	4.41 To 5.17
30° To 400 C.	4.54 To 5.08
30° To 450 C.	5.03 To 5.37
30° To 500 C.	5.71 To 6.21

*As determined from cooling curves, after annealing in hydrogen for one hour at 900°C. and for 15 minutes at 1100°C.



For more information, turn to Reader Service card, circle No. 425

proper shape and size was first sputtered onto the substrate and then anodically oxidized to form a tantalum oxide dielectric film. A film of gold was then evaporated onto the dielectric to form the completed capacitor "sandwich."

Other research at Bell Laboratories indicates copper leads can be sputtered without difficulty to connect various components. In this application the technique is attractive because it eliminates the need for any organic adhesives.

In addition to pure metals, alloys such as nickel-copper and nickel-chromium can be sputtered without difficulty, apparently retaining their approximate original composition.

How it works

Although some disagreement still exists as to the exact mechanism of cathode sputtering, its effects can be easily described and recognized. These effects were first noted in 1852 by W. R. Grove, and in 1858 by J. Plücker.

In cathode sputtering, a plate of the metal to be deposited is used as a cathode. The substrate on which the film is to be deposited is placed close to the cathode. After evacuation, argon or another gas is introduced and maintained at a constant pressure. When a voltage is applied, ionized atoms of the gas bombard the cathode, dislodging metal atoms or clusters of atoms, which then deposit on the substrate.

With proper masking of the substrate, lines and patterns of practically any desired shape and size can be formed. The sputtered films generally are between a few hundred and a few thousand angstroms thick.

Stabilized Ceramics Withstand High Heat

Three stabilized ceramic materials have been developed by Norton Co., Worcester 6, Mass. for use at temperatures up to 4000 F. The ceramics —one a coating—are said to have good thermal shock resistance and good wear and chemical resistance. They are particularly useful in rockets and missiles. The three materials are:

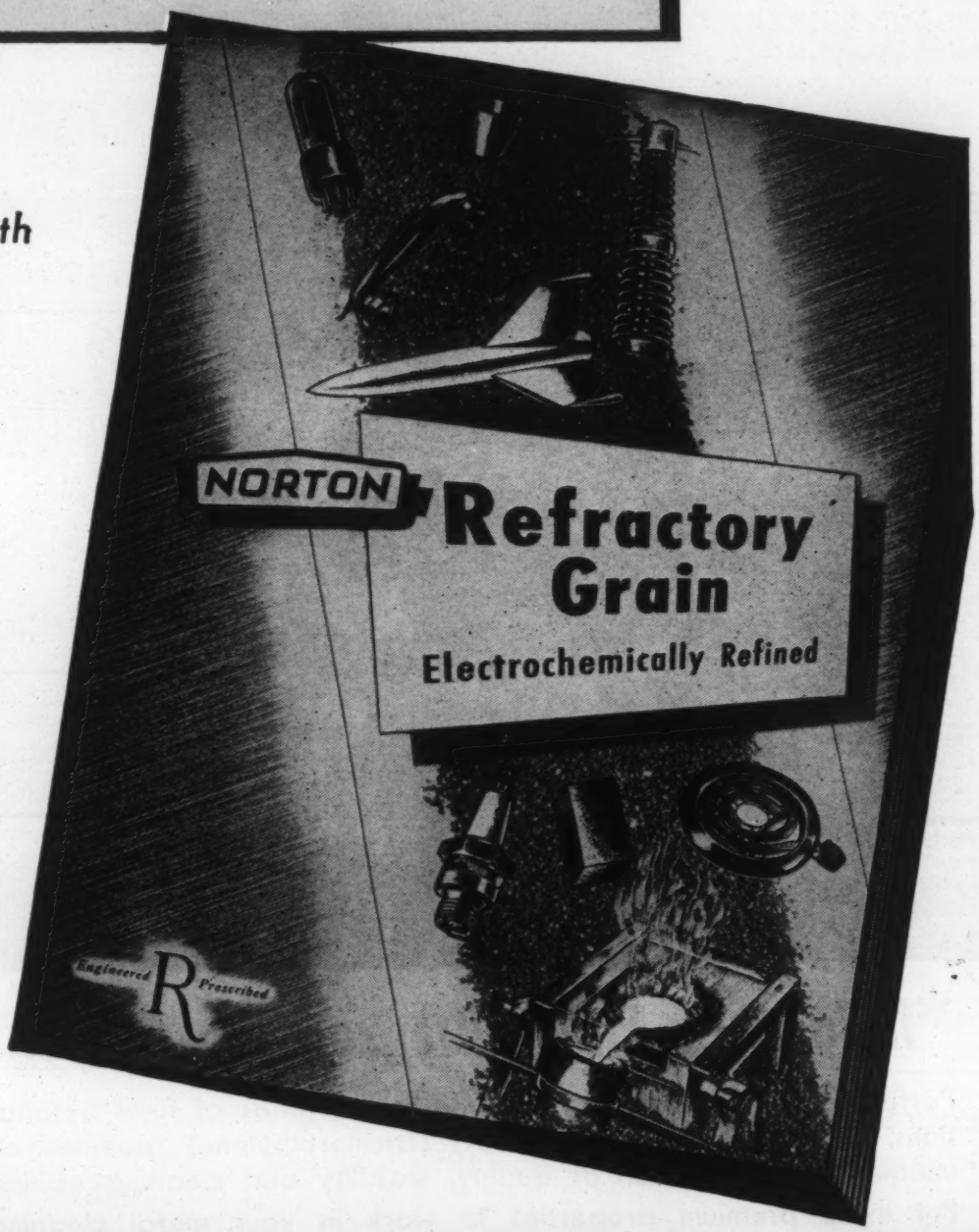
Crystolon N: a nitride-bonded sili-

You May Profit From This Book

✓ *if you are concerned with processing that involves temperatures ranging upwards to 4000°*

✓ *if your progress in processing depends upon materials of high purity.*

✓ *if it would help you to obtain a modern material with unusual electrical characteristics.*



Here is a valuable reference book that tells you all about the chemical and physical characteristics of such materials as CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, Fused Zirconia and Boron Carbide.

Describing how these electrochemically refined materials react under varying conditions, this book gives you plenty of facts on materials that are helping to solve processing problems.

Get this useful help towards solving your own processing problems. Write today for your free copy of "Norton Refractory Grain." NORTON COMPANY, Refractories Division, 351 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

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PERM-A-CLOR (NA)*

*Industry's Finest Degreasing Solvent

Perfected in the laboratory, proven in thousands of field installations, DETREX PERM-A-CLOR (NA) (Trichlorethylene) provides an unequalled combination of quality, stability and cleaning ability.

Put these premium properties to work in your metal cleaning operation and you are assured of substantial savings in operating and maintenance costs plus increased quality.

Take advantage of DETREX's field service and years of experience in *every* phase of metal cleaning and processing to save your company thousands of dollars.

Depend on DETREX for Every Metal Cleaning and Processing Need

PERM-A-CLOR (NA) (Degreasing Solvent)..
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Phosphate Coatings and Paint Bond Compounds
Alkali and Emulsion Cleaners
Rust Proofing Oils and Compounds
Ultrasonic Equipment
Industrial Washers
Extrusion and Drawing Compounds
Spray Booth Compounds
Aluminum Finishing Compounds

DETREX CHEMICAL INDUSTRIES, INC.

BOX 501, DEPT. MM-12 DETROIT 32, MICHIGAN

For more information, turn to Reader Service card, circle No. 392

PROPERTIES OF CRYSTOLON CERAMICS

Type ➡	N	R	C
Ten Str, psi..	3,500	5,500	—
Mod of Rupture, psi...	6,000	10,000	—
Mod of Elast, 1000 psi...	20	23	—
Compr Str, psi	25,000	25,000	—
Knoop Hardness (100 gm).....	2500	2500	2500
Porosity, %..	19	21	—
Density.....	2.6	2.5	1.7
Max Svc Temp, F...	2900	4200	4000
Ther Cond, Btu/hr/sq ft/°F/in....	66.7	130	100
Coef of Ther Exp, per °F.	2.8×10^{-6}	2.8×10^{-6}	Depends on graphite
Ther Shock Res.....	Good	Excellent	Excellent

con carbide ceramic. Chief characteristics of the material are: 1) it is relatively inexpensive; 2) it is not readily wetted by molten alloys; 3) it has little change in physical dimensions during firing; and 4) it can be made into a variety of shapes and sizes. (For information on another nitride-bonded silicon carbide, see MATERIALS & METHODS, Nov. '54, p 83).

Crystolon R: a recrystallized or self-bonded silicon carbide. Chief property of this material is its ability to withstand extreme heat and thermal shock. It can be used at temperatures up to 4200 F and even higher for short periods of time, according to the producer. The material also has good abrasion resistance and excellent high temperature strength. (For information on another self-bonded silicon carbide, see MATERIALS & METHODS, Oct '56, p 92.)

Crystolon C: a pure, self-bonded silicon carbide coating that is applied to graphite. The coating is said to make graphite oxidation resistant at high temperatures. The coating is formed by a high temperature chemical reaction causing it to be an integral part of the graphite. The coated graphite retains most of its inherent properties, including low density, because the ceramic coating is very thin (0.003 to 0.020 in. thick). Possible applica-

The difference?...

CORROSION PROTECTION *with* SOLVAY SODIUM NITRITE

Sodium nitrite protects steel—whether it is in the fine strands of steel wool, or in plates, pipes, or in machined parts such as gears. The *only* difference between the specimens shown above is that the beaker on the left contains a low cost .1% concentration of SOLVAY Sodium Nitrite.

SOLVAY Sodium Nitrite forms an invisible gamma oxide protective film that keeps metal surfaces corrosion-free. You can easily dip or spray it in solution, or add it to circulating water systems. Effective with steel or iron, it also reportedly suppresses degradation in aluminum, tin, monel, copper and brass. Where a more moisture resistant film is required, it can be combined with phosphates.

Write for test sample and full facts on SOLVAY Sodium Nitrite's many anti-corrosion applications.

Mail now for sample, information!

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

Please send me without cost:

- ☐ Test sample of SOLVAY Sodium Nitrite
- ☐ Booklet—"Sodium Nitrite for Rust and Corrosion Prevention"

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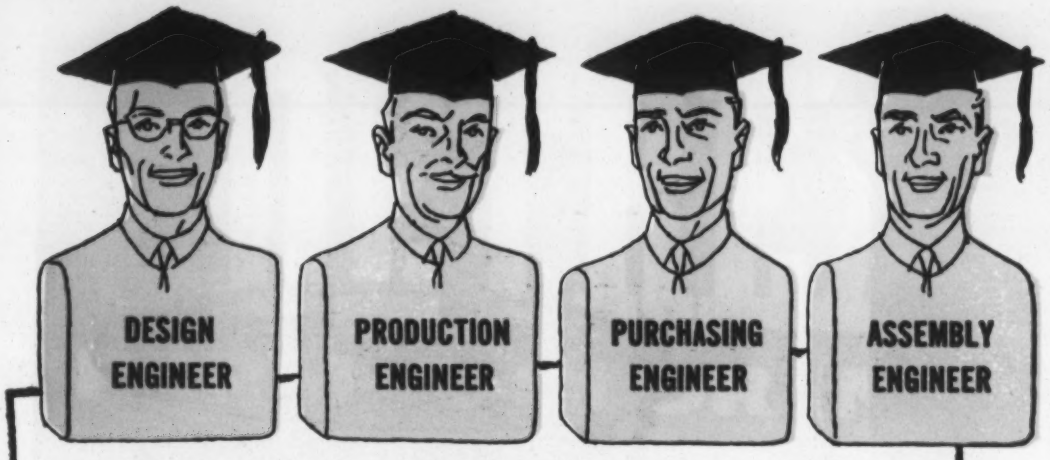
Sodium Nitrite • Calcium Chloride • Chlorine • Caustic Soda • Caustic Potash Chloroform • Potassium Carbonate • Sodium Bicarbonate • Vinyl Chloride • Methyl Chloride • Ammonium Chloride • Methylene Chloride • Monochlorobenzene Soda Ash • Para-dichlorobenzene • Ortho-dichlorobenzene • Carbon Tetrachloride Ammonium Bicarbonate • Snowflake® Crystals • Aluminum Chloride • Cleaning Compounds • Hydrogen Peroxide • Mutual Chromium Chemicals

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N.Y.

SOLVAY dealers and branch offices are located in major centers from coast to coast.

For more information, turn to Reader Service card, circle No. 471



THOSE IN THE KNOW, KNOW

There's **NO** time waste

There's **NO** machining

There's **NO** grinding

There's **NO** counting

There's **NO** stacking

There's **NO** miking

and there's NO dirt between layers—ever, for those who say

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Laminated Shims of **LAMINUM** now available in

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the solid Shim that p-e-e-l-s for adjustment

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STAINLESS STEEL	ALUMINUM	BRASS	MILD STEEL
with laminations of .002" or .003"	with laminations of .003" only	with laminations of .002" or .003"	with laminations of .002" or .003"

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tions for Crystolon C coatings on graphite are combustion and thrust chambers, high voltage electrodes, crucibles and rocket motors.

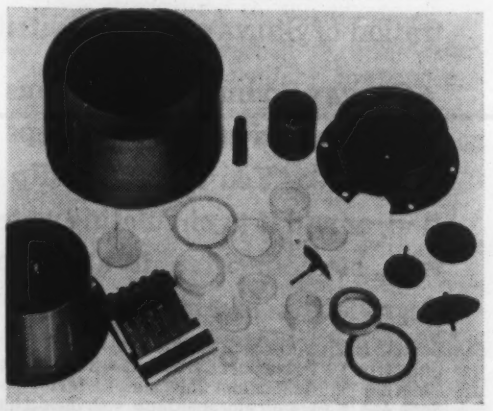
Metals Research Aims at Ductile Beryllium

With designers of advanced aircraft and missiles growing more and more enthusiastic about lightweight beryllium, metallurgists are trying hard to make the material less brittle.

Two experimental forms

One important center of such work is Nuclear Metals' new research and development laboratory in Concord, Mass. (see article, p 177). A recent development: a piece of beryllium sheet containing parallel slits not much more than ¼ in. apart. Having found that narrow strips of the metal could be bent much further without cracking than wider strips, Nuclear Metals' investigators designed the slit sheet that looks much like a draftsman's erasing shield. Now they are trying to see if they can increase the load-carrying capacity by filling in the slits with a more ductile material, such as aluminum.

Another experimental form of beryllium developed by this company is a small H-beam about ¾ in. in height. This extruded beam, according to A. R. Kaufmann, vice president and technical director, has "a



Close tolerance rubber parts—The variety of silicone rubber parts shown above are said to be molded to extremely close tolerances. The parts are available from Sierra Engineering Co., 123 E. Montecito St., Sierra Madre, Calif.

ANOTHER NORTHWEST FIRST!

Completely NEW concept in metal cleaning!

- An easy handling liquid.
- Effective on *all* metals.
- Requires NO special tanks or equipment.
- A completely organic product.
- Won't injure rack coatings or work finish.
- Simple positive control.

Alkalume LC-1 is a specially developed immersion-type cleaner for removal of buffing compounds and soil from all metals, prior to plating or anodizing.

It is non-solvent, non-alkaline and not an emulsion. It has the desirable penetrating properties of both alkali and solvent yet affords complete protection for the surface finish.

Alkalume LC-1 is economical, non-toxic and non-volatile, offering long service life and no disposal problem.

Complete details upon request.

The name NORTHWEST means first with the best!

LO HI pH

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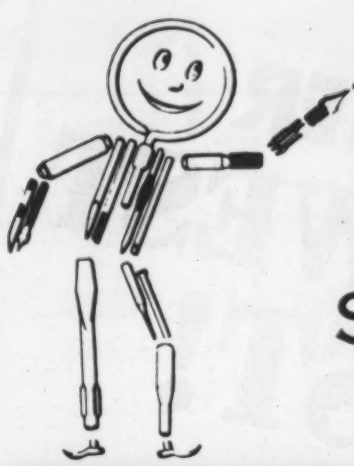
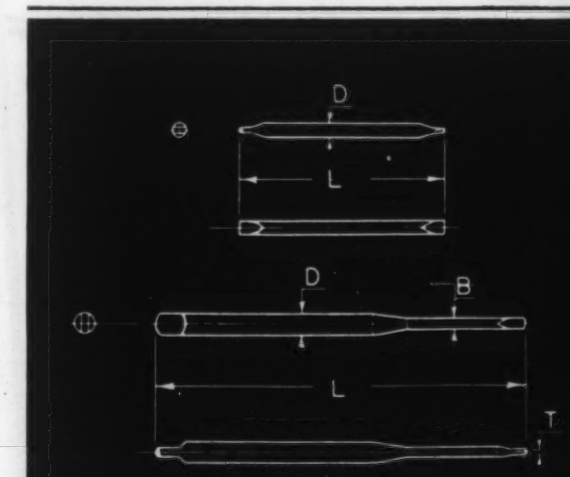


NEWS
from Torrington on
SMALL PRECISION METAL PARTS



DOUBLE END BLADES

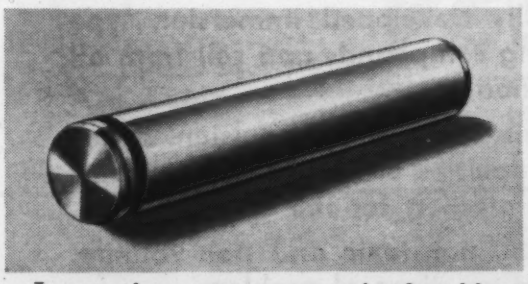
D = .024" to .060"
L = 5/8" to 2"

JEWELERS' BLADES

D = .098" to .1875"
B = .025" to .100"
L = 1-9/16" to 3"
T = .004" to .015"

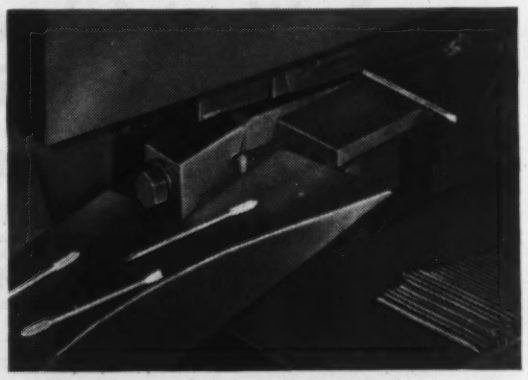
"Custom manufacture" has a special meaning at Torrington, where our Specialties Division produces a tremendous variety of small precision metal parts. For our engineers often help in designing parts for our customers, and as frequently develop special equipment or methods for most efficient production.

For example, one of our current contracts is for jewelers' screwdriver blades. In this case, our engineers decided to swage these parts to give the required high-strength characteristics without stress concentration points and tool marks. Other features of these parts are good dimensional accuracy and closely controlled heat treating for hardness and temper.



In another case, we received a blueprint of a special pinion axle with an accurately cut retaining ring groove at one end. The customer inquired whether this part could be produced at about the same price as a straight cylindrical axle with an uninterrupted OD. The answer was "Yes!" Specialties engineers decided that high-speed cutoff and groove-turning equipment would have to be built to cope with the high volume involved. Special pinion axles have now joined the great number of parts being produced by Torrington Specialties Division.

Whatever the part, whatever the operation—even operations tailored to the part requirements—Torrington's Specialties Division is uniquely equipped to handle your small precision parts contracts. Highly specialized fluting opera-



tions, for example, permit volume production to close tolerances. Precision swaging, knurling, forming, milling, drilling are among other operations for which we are fully equipped. Advanced heat treat and statistical quality control methods help provide the quality product you require.

For help with your custom-built small precision metal parts in large quantities, just circle our number on the reply card. Or have your Purchasing Agent call our area salesman, or write direct to:

The Torrington Company, Specialties Division, 777 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

For more information, turn to Reader Service card, circle No. 453

surprising amount of deflection."

Dr. Kaufmann warns: "It is difficult to predict that beryllium will ever have as much ductility as common structural metals. On the other hand," he says, "there is a good chance that beryllium will find engineering use, providing that engineers will change their present design standards and will go out of the way to live with the material."

A broader look ahead

Other possible developments in materials foreseen by Dr. Kaufmann:

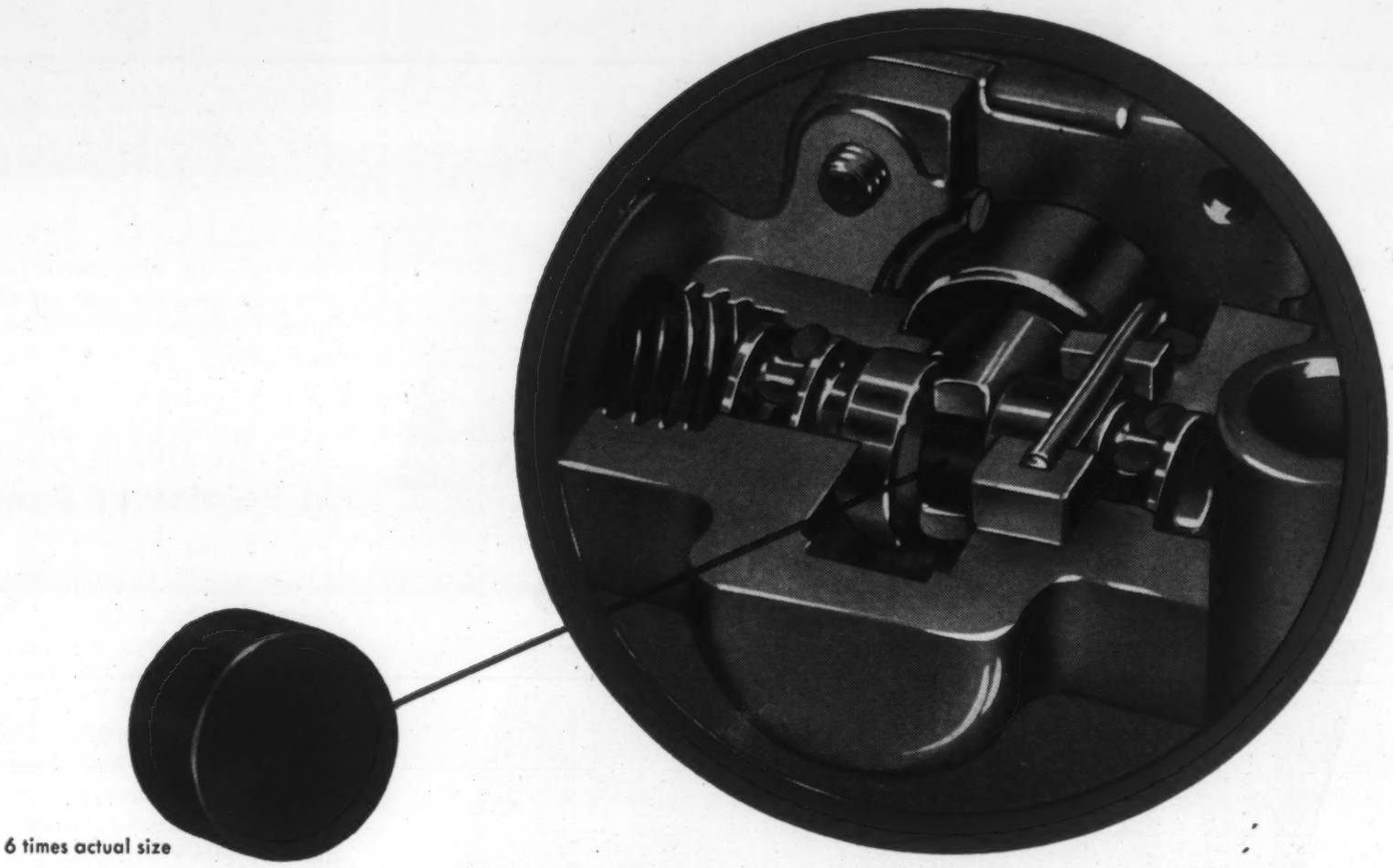
- Highly efficient power reactors using molten uranium or plutonium fuel. Likely materials for containing these hot, corrosive fuels: yttrium for uranium, and tantalum or vanadium for plutonium.
- Development of graphite into a valuable high temperature structural material. Unlike other materials, graphite becomes stronger and more ductile above 3000 F.
- Development of tungsten, molybdenum, tantalum and columbium to the point where sheet, bar and tubing are readily available.
- Increasing use of composite materials combining the advantageous properties of two or more metals.

Nuclear Metals itself has coextruded many combinations of materials. Typical combinations: 1) a nuclear fuel element tube of uranium clad inside and outside with 15 mils of zirconium, and 2) a thin-wall tube of molybdenum clad with stainless steel. Other possibilities of Nuclear Metals' coextrusion process are outlined in an article in this issue, p 91.

Titanium Castings

Commercial production of titanium castings has begun at Harvey Aluminum Co., 19200 S. Western Ave., Torrance, Calif.

To make castings, Harvey uses a closed consumable electrode furnace in which a high vacuum or inert gas atmosphere is maintained to protect the metal from oxygen or nitrogen. The company says it is able to melt and cast titanium alloys without carbon or tungsten contamination, thereby improving ductility, reducing hardness and



6 times actual size

FOR PRECISION OPERATION

VALCOR solenoid valve relies on a self-lapping GRAPHITAR® disc.

(CARBON-GRAPHITE)

These solenoid valves manufactured by Valcor Engineering Corp. of Kenilworth, New Jersey, incorporate a "floating seal" of GRAPHITAR, and are helping to launch the new age of guided missiles in America. Over half a million Valcor valves are in use in military aircraft and guided missiles today.

The heart of the "floating seal" solenoid valve is a precise, optically flat, GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. The solenoid valve actually improves with use, due to its unique self-lapping action.

GRAPHITAR has many unusual properties that make it an ideal material for such challenging applications. It is nonmetallic; resists chemical attack; is mechanically strong, yet extremely light in weight. GRAPHITAR will not warp and extreme changes in temperature cause virtually no expansion or contraction. Probably the most important of GRAPHITAR'S advantages are its self-lubricating properties and low coefficient of friction.

Today design engineers are solving many different problems by using GRAPHITAR, a most unusual and versatile engineering material. Perhaps GRAPHITAR is the perfect material for your product. Our competent staff of engineers can assist you in applying GRAPHITAR to your particular needs.

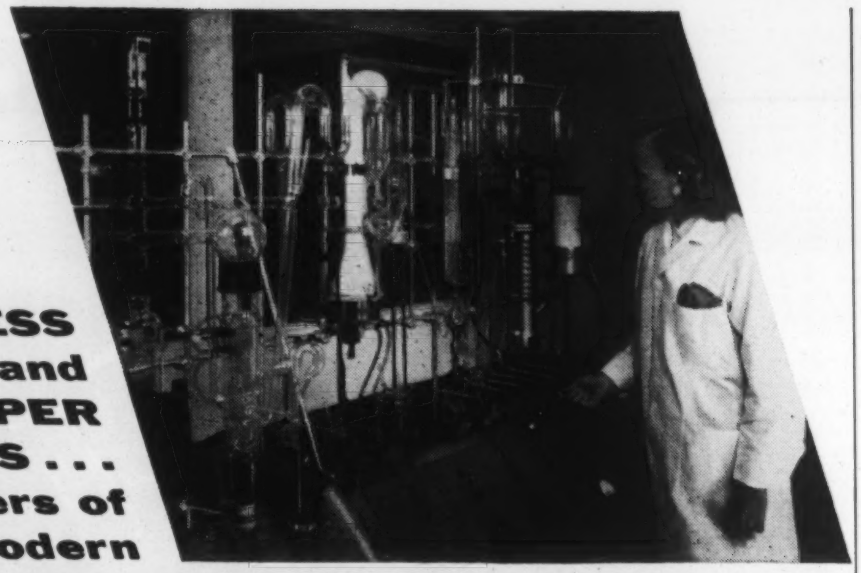
Detailed design data with typical applications, properties and characteristics of GRAPHITAR, are included in Bulletin #20. Write us today—on your letterhead —for a free copy.

R-258-1

THE UNITED STATES GRAPHITE COMPANY

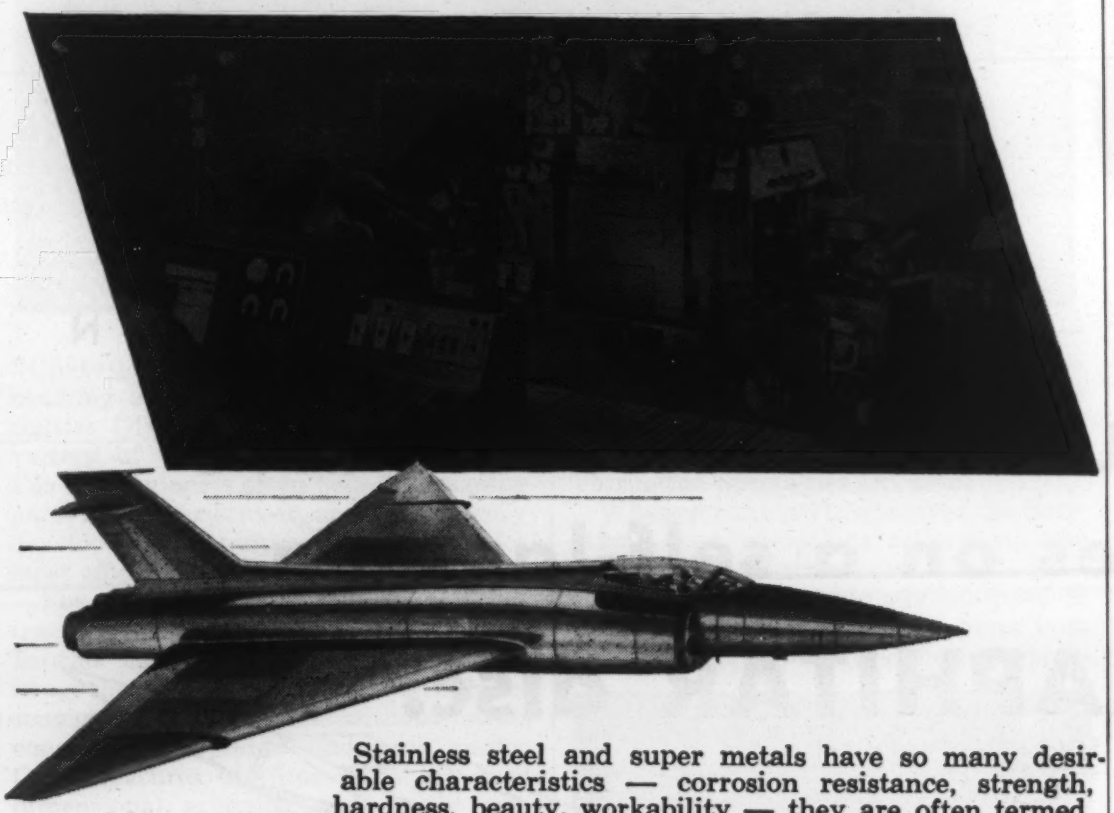
DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



STAINLESS STEEL and SUPER METALS . . . workers of modern

miracles

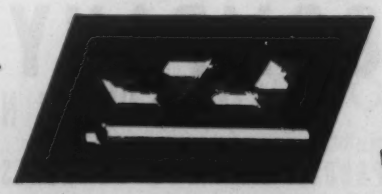


Stainless steel and super metals have so many desirable characteristics — corrosion resistance, strength, hardness, beauty, workability — they are often termed "miracle metals." But they can perform miracles *only if you select the right analysis for your particular application.* Wallingford is more qualified than ever to help you do this. Now, an all-new metallurgical laboratory and a larger staff of expert technicians are at your service.

In such fields as nucleonics, aviation and guided missiles, stainless steel and super metals will accomplish miracles *only when gages can be held to the close tolerances demanded.* Wallingford's Sendzimir Mills, equipped with non-contacting, continuous gages, assure this. A feed-back system provides fully automatic correction of the mills to maintain strip thickness with required tolerances at all times. These mills make Wallingford one of the few companies capable of producing precision strip in widths up to 27" and as thin as .001" . . . and give Wallingford the largest foil capacity in the country.

Investigate Wallingford's ability to provide stainless steel and super metals that will perform "miracles."

THE WALLINGFORD STEEL CO.



Progress in Metals for over 36 Years

WALLINGFORD, CONN., U.S.A.

COLD ROLLED STRIP: Super Metals, Stainless, Alloy

WELDED TUBES AND PIPE: Super Metals, Stainless, Alloy

For more information, turn to Reader Service card, circle No. 460

making the cast parts easier to machine. Harvey also produces titanium forgings, extrusions, bars, rods and tubing.

Acrylic Resin Used in Reinforced Panels

Reinforced plastic panels made of a new acrylic resin previously discussed in this magazine (Mar '58, p 149) will soon be marketed by Naugatuck Chemical Div., U. S. Rubber Co., 1230 Avenue of the Americas, New York 20. The panels, called Tropiglas, are designed specifically for outdoor uses.

One-year exposure tests in Florida and other parts of the country show the panels have good weather resistance in all kinds of weather. The panels are reported to be extremely durable and have a smooth, glossy surface that is attractive and decorative.

Tropiglas panels will be made in sheet sizes up to 3½ x 8½ ft, and in thicknesses from 0.060 to 0.100 in. The panels will be translucent and will be supplied clear or in colors.

Method Checks Bond in Metallic Honeycomb

What is claimed to be an easy-to-use method for checking the bond in honeycomb structures has been introduced by Magnaflux Corp., 7300 W. Lawrence Ave., Chicago 31. The test, known as Bondcheck, is sold in kit form and is used most successfully on soldered, welded and brazed metallic honeycomb structures.

The test procedure works as follows:

1. The surface of a honeycomb structure is cleaned and sprayed with a specially formulated red fluid that is repelled by heat and tends to flow to the coolest area on a metal surface.

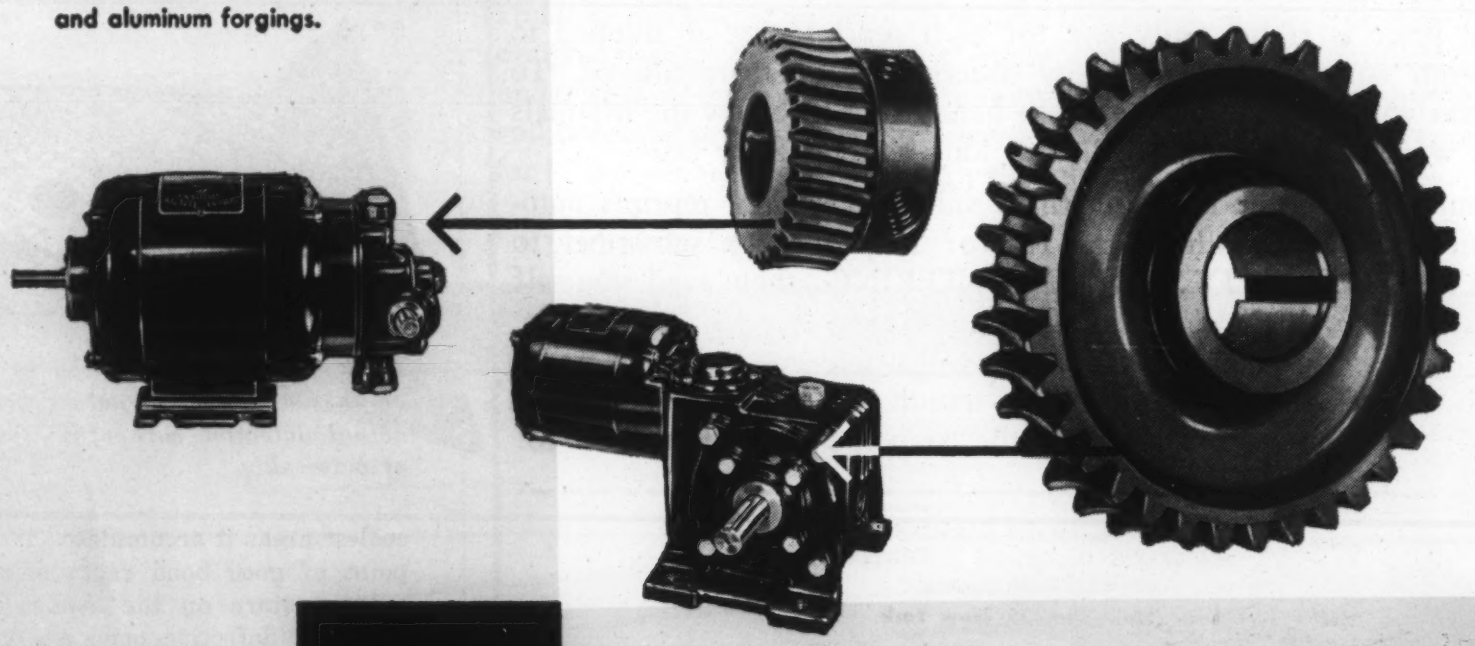
2. After application of the fluid, a controlled heat is applied from a high intensity infrared lamp. The heat is conducted from the surface being inspected to the honeycomb core wherever a good bond exists between the core and the surface. Since the visible fluid flows to the

MUELLER BRASS CO. forged gears improve dependability and performance of BODINE electric motors

For combined high shear strength and maximum wear life in their single and double reduction speed reducer motors, Bodine Electric Company of Chicago uses gears forged from Mueller Brass Co. 603 Alloy.

Bodine has specified Mueller Brass Co. forged gear blanks because of their consistently high quality . . . there is no porosity, foreign inclusions or defects typical of cast blanks. The hot working of the metal followed by heat treatment to the desired physical properties produces a refined grain structure to give uniform machining and wear in service. The forged blanks are consistent in size and held to close tolerances. Bodine has also found that the excellent machinability of the blanks in the hobbing operation increases overall hob life.

For forgings of high tensile strength, high density, minimum porosity, light weight, corrosion resistance, good machinability and low costs with little scrap loss, it pays to specify forgings from the Mueller Brass Co., the world's largest producer of brass, bronze and aluminum forgings.



only the man from Mueller Brass Co.

can offer unbiased advice on the "one best way" of producing your parts, because Mueller Brass Co. is the *only* fabricator in the country offering all these methods of production . . . assuring you the best product at the best price . . . made the one best way.

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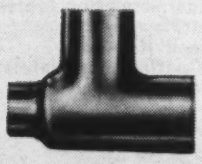

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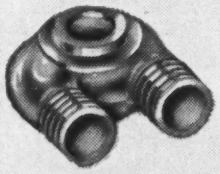

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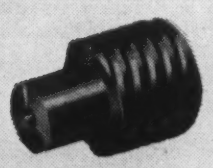

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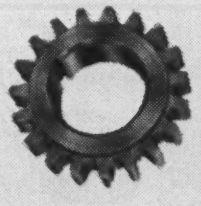

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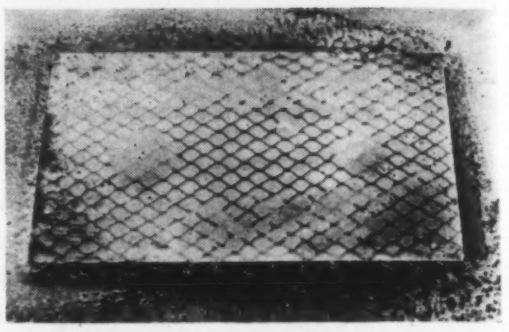
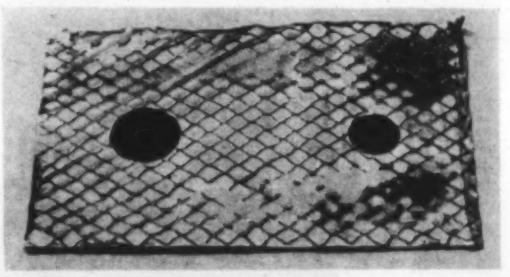


Void areas *on surface of a honeycomb structure that has been coated with a special fluid reveal lack of bond between skin and honeycomb core.*



Dark areas *corresponding to voids on the surface of structure indicate actual defective core after removal of outer skin.*

coolest areas it accumulates at every point of good bond reproducing an exact pattern on the bonded area. Areas of defective bond are visible as gaps in this pattern.

The test is said to take only a few seconds and can be used on complex shapes.

Silicone Fluid Stable from –25 to 550 F

A new silicone fluid, an alkyl silane has been developed by Dow Corning Corp., Midland, Mich. for use as 1) a high temperature hydraulic fluid in lubricating systems where oxygen is present in limited concentrations, 2) a high temperature turbine oil when formulated with suitable additives, and 3) a base fluid for the formulation of high temperature greases.

Designated QF-6-7009 Fluid, the material is thermally stable in closed systems for long periods of time at temperatures from –25 F to 550 F, and for shorter periods up to 700 F.

Properties

Lubricity—Shell 4-ball tests at 167 F and 400 F demonstrate that the

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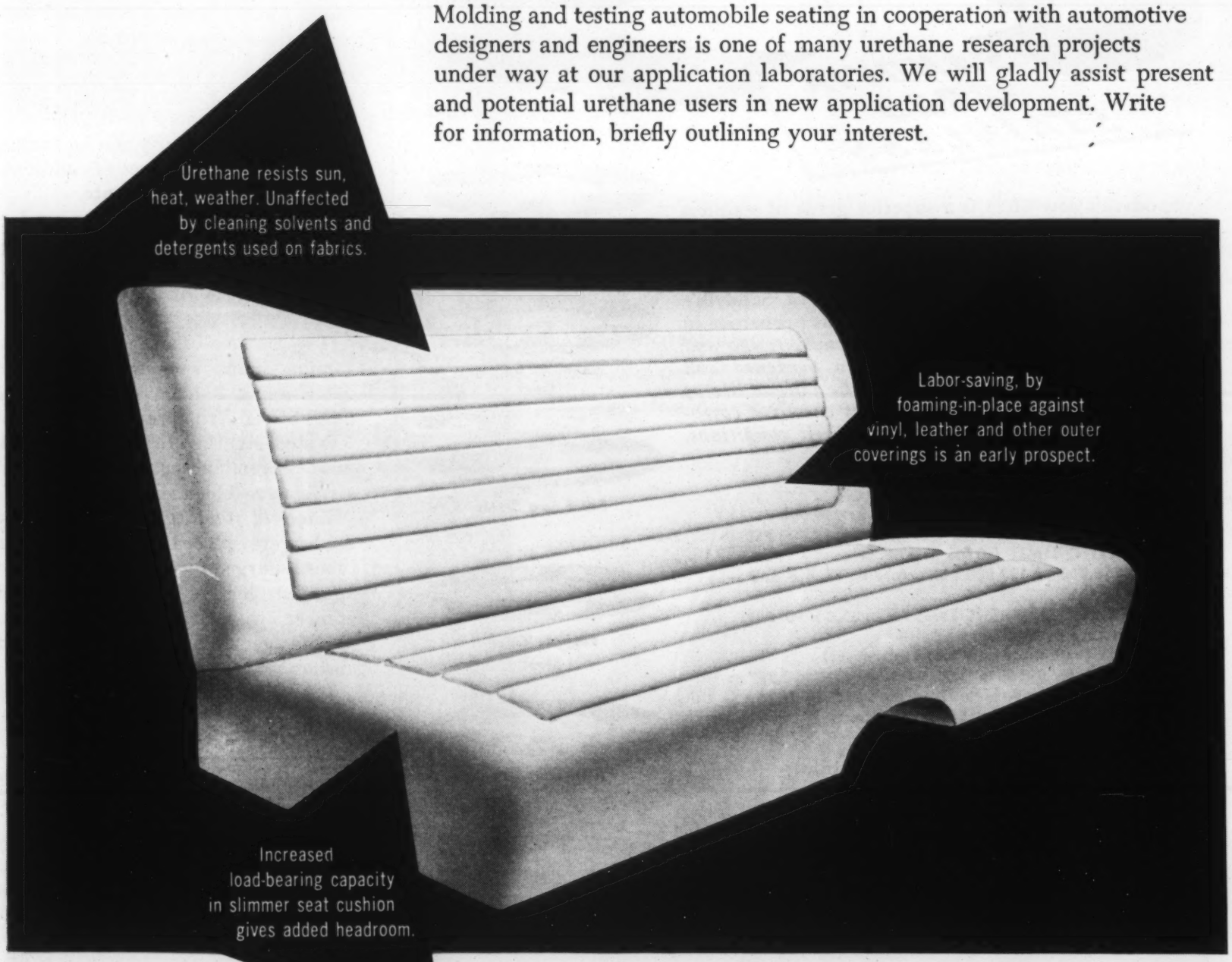
Urethane can combine showroom comfort with minimum road jounce. It eliminates fear of bottoming . . . reduces the sidesway in cornering that is usually associated with foam.

Molding and testing automobile seating in cooperation with automotive designers and engineers is one of many urethane research projects under way at our application laboratories. We will gladly assist present and potential urethane users in new application development. Write for information, briefly outlining your interest.



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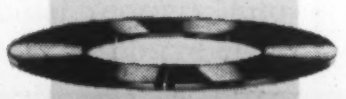
SANDVIK

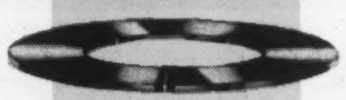
Presents A SUPER SPRING STEEL

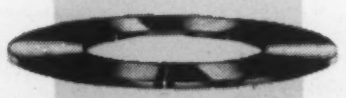
Sandvik's new 2R25 is a superior grade of stainless spring steel which goes far beyond the capabilities of ordinary spring steels. It was developed for applications where performance outranks cost.

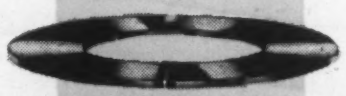
This new steel is a prime example of Sandvik's ability to combine several advantageous properties in one metal. *Sandvik 2R25 is exceptionally tough and resilient, much more formable than hardened and tempered steel, has up to 10 times the fatigue life of ordinary carbon spring steel and has excellent corrosion resistance under varying atmospheric conditions.*

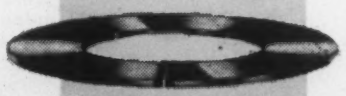
Mechanical Data on 2R25—
TENSILE STRENGTH RANGE—
Hard Rolled 242,000 • 270,000 or 299,000 PSI
Heat Treated 270,000 • 299,000 or 327,000 PSI
ELASTIC LIMIT (.01% Proof Stress)—From 156,000 to 192,000 PSI according to size and finish
MODULUS OF ELASTICITY—27.7 to 35.6 x 10^6 PSI according to size and finish
SIZES (with extremely close tolerances)
Thickness—.0016" to .035", Width—.039" to 3.94"
For further information on Sandvik 2R25, contact your nearest Sandvik office.

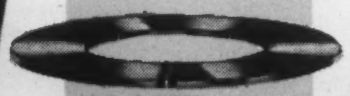

Hardened & Tempered Spring Steel

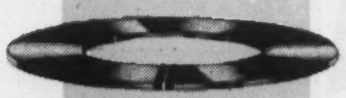

Annealed Spring Steel


Band Saw Steels


Flapper Valve Steel


Piston Ring Steels


Razor Blade Steel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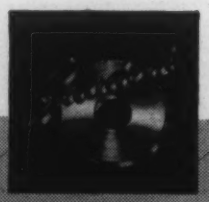

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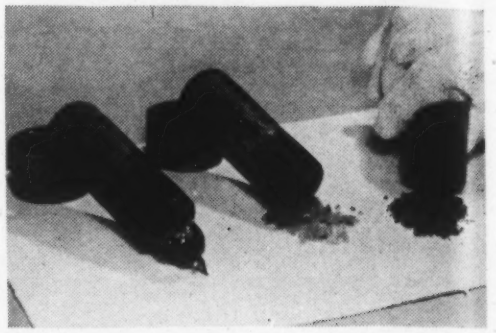


***Silicone fluid** (left) remains unchanged after aging 10 hr at 700 F. Silicate hydraulic base fluid (center) and diester turbine base fluid (right) exploded in less than 4 hr after aging at 700 F.*

lubricating ability of QF-6-7009 Fluid is reasonably good. The tests indicate that lubricity can be further improved by the use of additives such as tricresyl phosphate.

Oxidation, corrosion—The surface of aluminum, silver, titanium and copper strips remained unchanged after aging 24 hr at 500 F in the fluid; carbon steel strips were blued.

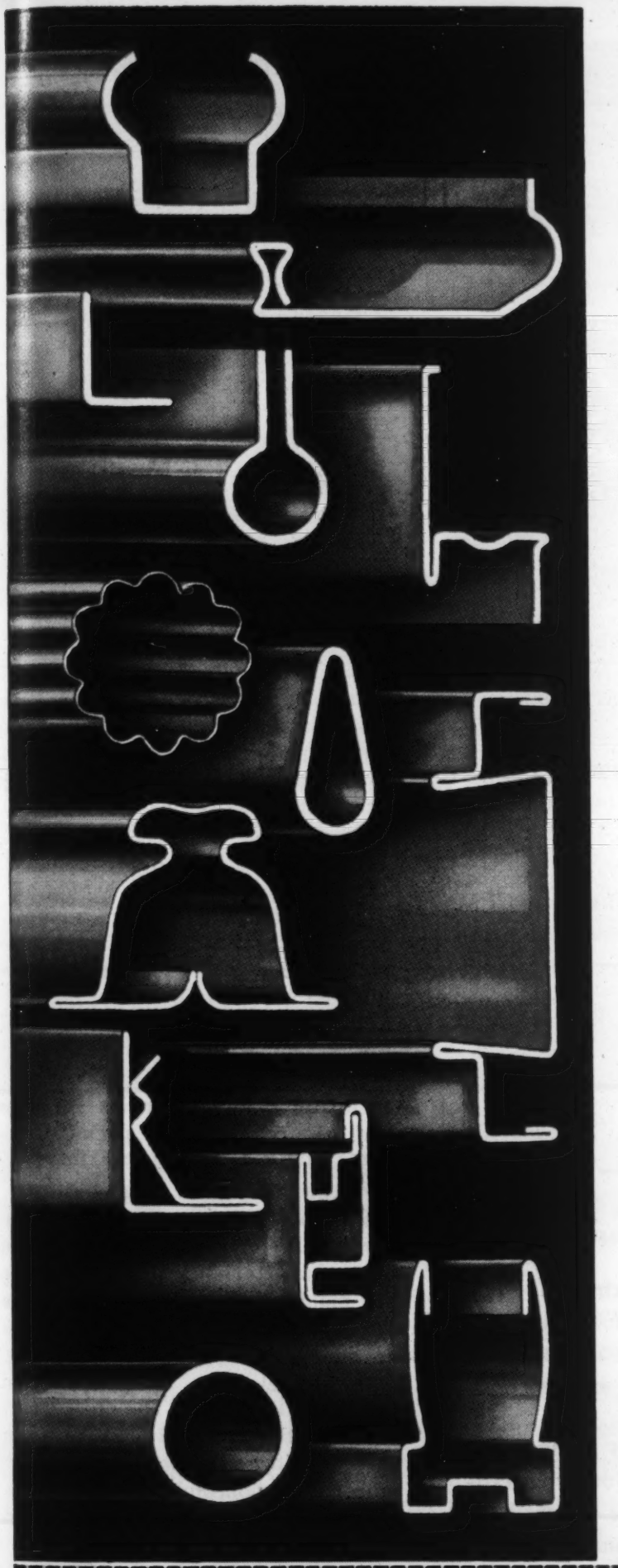
The surface of aluminum and titanium strips remained unchanged after aging 9 hr at 700 F in the fluid. Silver strips were dulled, stainless steel strips were slightly stained, and chromium-molybdenum steel strips were blued.

Thermal stability—Samples of the fluid were placed in closed glass tubes, purged with nitrogen and aged at high temperatures. Acid number, viscosity and color of a sample aged 24 hr at 550 F remained unchanged.

The acid number of a sample aged

PROPERTIES OF QF-6-7009

Specific Gravity	0.90
Color	Clear straw
Viscosity, cs	
0 F	1500
77 F	70
100 F	38
210 F	6.3
400 F	1.7
700 F	0.65
Freeze Point, F	—30
Flash Point, F	500
Fire Point, F	550
Spontaneous Ignition Temperature, F	690
Acid Number	0.03
Refractive Index	1.506
Vapor Pressure, mm Hg	
500 F	18
600 F	55
700 F	300



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In this 48 page handbook you'll find useful engineering and fabricating data including practical examples showing where, when and how Van Huffel Roller Die, Cold Formed Metal Shapes simplify design, increase production and reduce costs. It includes information on material selection, machine operations on shapes, fabrication methods, tolerances for roll forming, and dozens of interesting illustrated ideas that have taken shape in metal.

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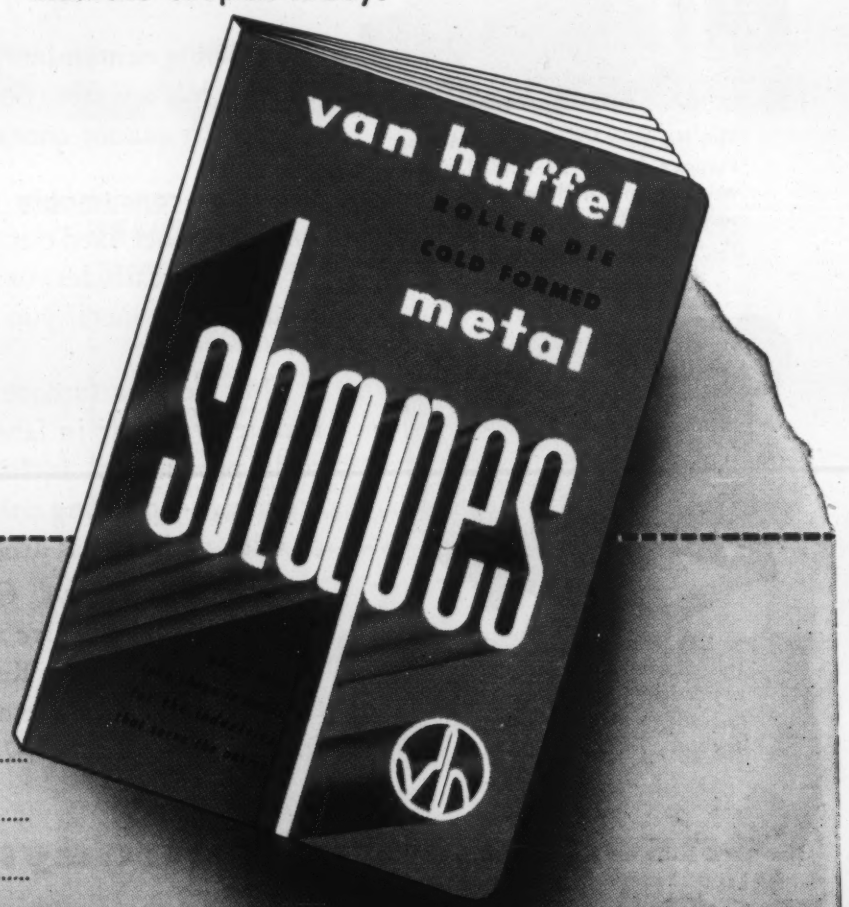

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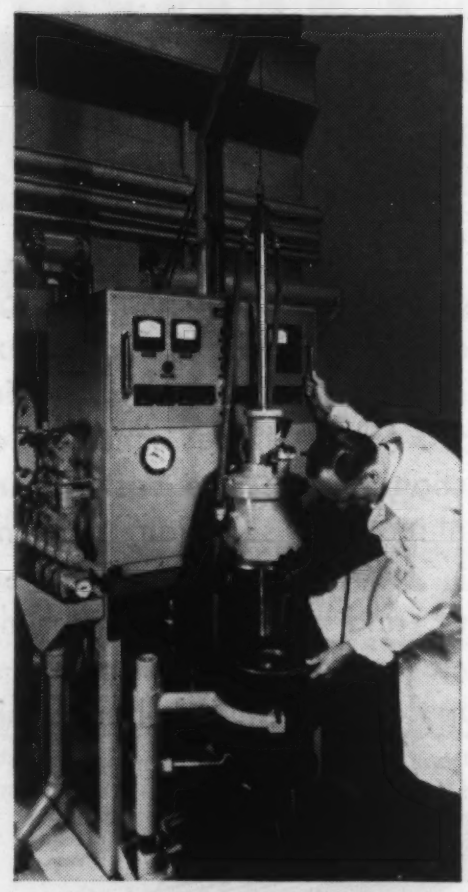
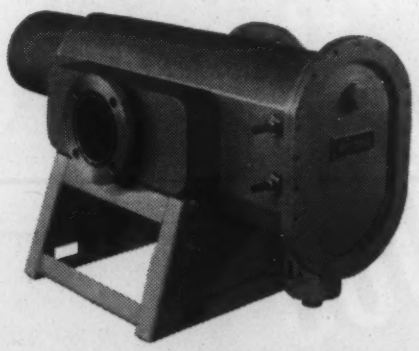
Cr, Hf, Ir, Mo, Nb, Os, Pd, Pt, Re, Ta, Ti, V, W, Zr

Get pure vacuum melts of these metals *in minutes!*



The Heraeus Vacuum Arc Melting Furnace Model VA-L200H, smallest of a line of Heraeus Furnaces sold by CEC.



This Roots pump maintains low, vapor-free pressures. A motor *operating within the vacuum* drives its rotary frictionless pistons.

With this new Heraeus Arc Melting Vacuum Furnace, the VA-L200H, you can get vacuum melts in "buttons" or ingots.

You can get them of Titanium, Zirconium, Tungsten, and other metals or alloys with high melting temperatures. You can get them fast and pure.

Super-fast mechanical pump—A Roots mechanical vacuum pump pulls pressures in the furnace down to 5 x 10^{-4}mm Hg—*fast*.

Its throughput of 10,400 micron CFM at 10 microns easily handles sudden gas bursts encountered with certain metals.

No oil contamination—The Roots pump's frictionless rotary pistons require no oil sealing. There can be no contamination from backstreaming vapors in the system.

No crucible contamination—The Heraeus furnace has a water-cooled, copper crucible which cannot contaminate the melt.

Fixed or consumable electrodes—You may use either fixed electrodes of tungsten or metallic carbides, or consumable electrodes of the metal you are melting.

This Heraeus furnace has many other features valuable in laboratory or small-scale production, including exceptional economy—operating either under vacuum or with an inert gas atmosphere.

Heraeus of Hanau, Germany, has licensed CEC as exclusive agent for Heraeus Arc Furnaces (and Roots Pumps) in this country. Complete details in our Bulletins P8-20 and P4-28.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N.Y.

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9 hr at 700 F also remained unchanged, whereas viscosity had a change of −30% and color darkened slightly.

Polystyrene Resins Repel Dust Patterns

Development of "low static" polystyrene resins that are said to practically eliminate the electrostatic fields which draw dust and arrange it in unsightly patterns on the surfaces of molded pieces has been announced by Monsanto Chemical Co., Plastics Div., Springfield, Mass.

Designated as Lustrex Lo-Stat, the materials are available in two general purpose formulations: 22, a standard molding grade, and 29, a formulation with good heat resistance. Molding and physical properties of the two resins are comparable to those of conventional general purpose polystyrenes.

The low static polystyrene resins are recommended for such applications as displays, clock housings, furniture drawers, grilles for fans and air conditioners, package closures and record player arms.

How resins repel dust

Company scientists explained that the affinity of polystyrene for dust is a characteristic acquired during the molding operation; parts leave the injection machine with an excess or deficiency of surface electrons.

If this electron imbalance could distribute itself over the entire part it would stabilize as a weak, uniform charge. However, because polystyrene is a nonconductor the nonuniformity of its electrostatic field is retained.

In some surface areas the static charge remains strongly positive; in other areas it is strongly negative. In either case dust particles are forcefully attracted and tightly held. The dust build-up actually "draws

Correction

The reference given for a synthetic sapphire growing technique in the Sept '58 issue, p 146, line 2, is incorrect. It should be M/DE, Sept '57, p 161.

THERMAFLOW® 105

HERE'S a high-strength reinforced molding compound that gives you a new slant on products you now make of die-cast metal, other plastics or by complicated sheet metal assemblies. Now Thermaflow 105 offers you flexural and impact strength ample for most uses, along with improved surface and excellent corrosion resistance . . . at a 20% saving over previously available compounds.

It's an "idea material" that pays off in improved quality and economy . . . in housings for appliances, television sets, radios, air conditioners, instruments . . . tanks, tubs, buckets, panels. You name it . . . we'll help you do it.

DESIGN DATA ON THERMAFLOW 105

	ASTM Bar	⅛" Random Cut Specimen
Impact strength ft.-lb./in. (Izod, notch)	12.0	4.5
Flexural strength	20,000	16,000
Heat distortion	>450°F	>450°F

Our new Technical Bulletin on T-105 gives the complete low-down on this remarkable compound. Write for your copy *now*.

ATLAC THERMAFLOW

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ATLAS POWDER COMPANY
Chemicals Division
Wilmington 99, Delaware

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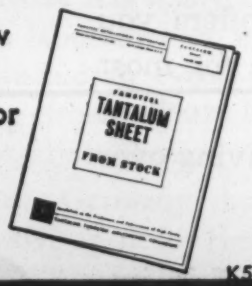

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NORTH CHICAGO, ILLINOIS, U. S. A.

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What's new IN MATERIALS

PROPERTIES OF LUSTREX RESINS

Type ➡	Lo-Stat 22	Lo-Stat 29
MECHANICAL PROPERTIES		
Tensile Strength, psi....	6800	6500
Elongation, %.....	1.8	1.9
Mod of Elast in Tension, 10^5 psi.....	4.5	4.6
Flexural Strength, psi...	10,100	11,000
Izod Impact Strength, ft-lb/in.....	0.29	0.30
Heat Distortion Temp, F.	174	176
ELECTRICAL PROPERTIES		
Dielectric Constant.....	2.58	2.45
Dissipation Factor.....	170×10^{-5}	17×10^{-5}
Dielectric Strength,v/mil	492	511

a picture" of these highly charged areas.

The scientists say low static polystyrene resins are formulated so that the molded surfaces are sufficiently conductive to allow most of the positive and negative charges to neutralize one another. Thus the forces which draw dust and make it cling in unsightly patterns are virtually eliminated.

Seal Makes Hydraulic Fittings Leakproof

A metallic seal that looks like an ordinary washer has been developed as a sealant for missile and aircraft control systems. The seal deforms and becomes an integral part of hydraulic fittings with the application of torque.

Made of aluminum, stainless steel and Inconel X, the seal is said to make hydraulic fittings leakproof from -360 to 1200 F and from 0 to 10,000 psi, depending on the material used. Developed by North American Aviation, Inc., the seal will be sold under the name of Natorq by Navan Products Inc., Santa Monica, Calif.

New Property Data for Thermal Insulations

The Magnesia - Silica Insulation Mfrs. Assn. (Engineering & Research Comm.) has issued new data on the physical and thermal properties of 85% magnesia, calcium sili-

Cut Finishing Costs THROUGH INCREASED PRODUCTION

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Positive pressure and exact registration of the part in the mask. Reduce rejects. Free both hands for productive movements.

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Increase production hundreds to one over hand methods. Reduce labor costs. Eliminate need of experienced workmen.

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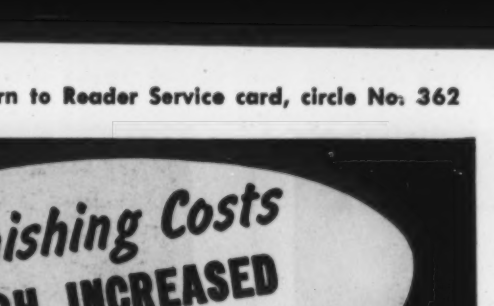

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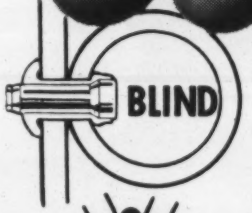

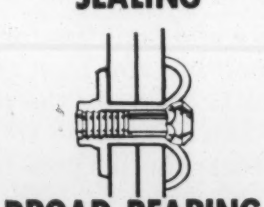

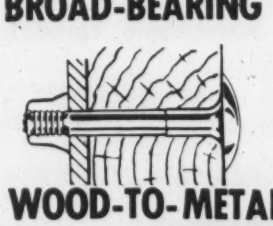

Huck's continuing research and development program offers today's designing engineer the last word in fastening materials and methods, even anticipating problems not yet evident on the drawing board.

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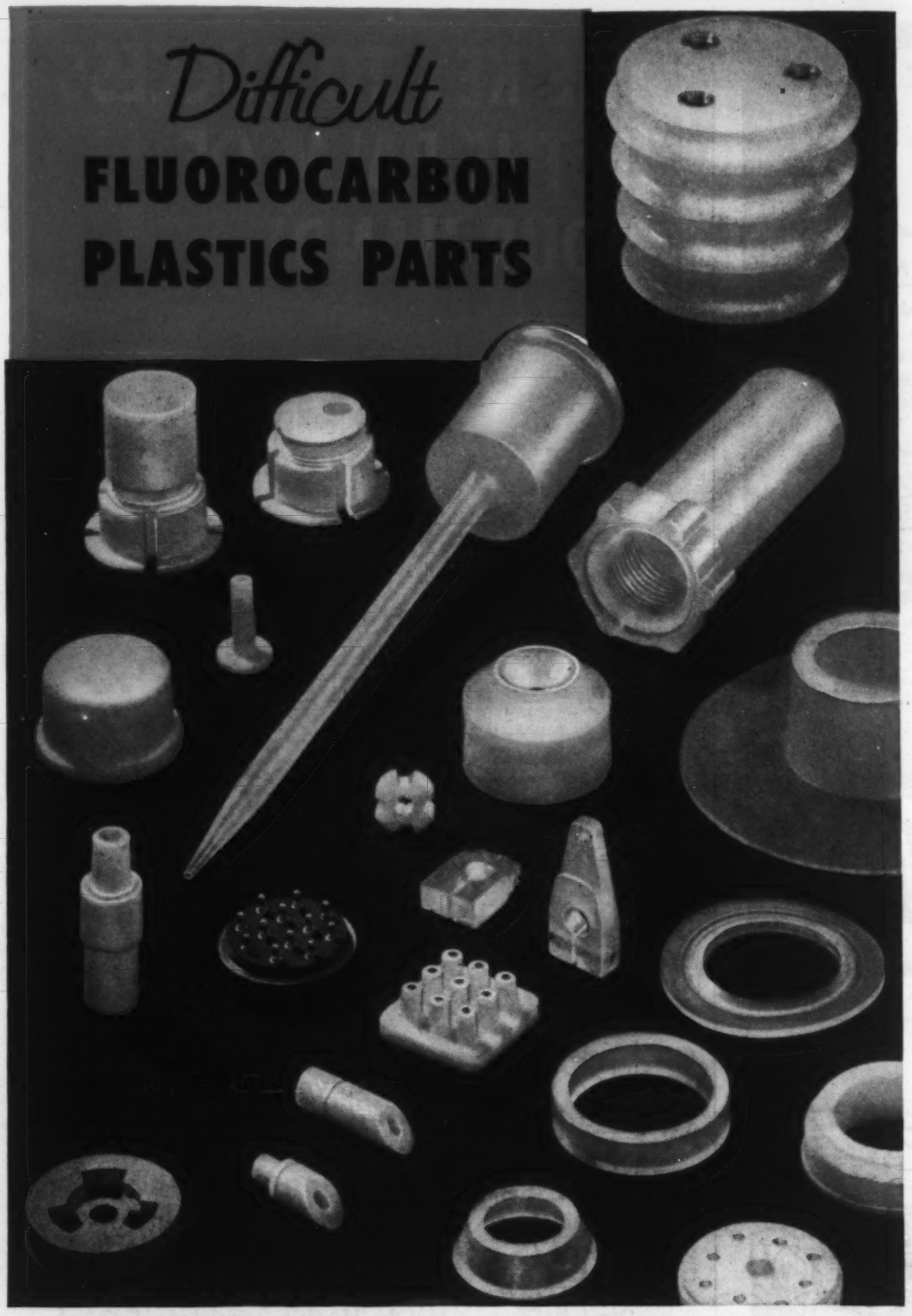

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For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

United States Gasket Company
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United States Gasket *Plastics Division of* **GARLOCK**

For more information, turn to Reader Service card, circle No. 407

What's new IN MATERIALS

PROPERTIES OF THERMAL INSULATIONS

Type ➡	85% Magnesia	Calcium Silicate	Diatomaceous Silicas	
PHYSICAL PROPERTIES				
Density, lb/cu ft	11	12	22	24
Flex Str, psi	45	50	75	70
Compr Str (5% def), psi	50	60	95	85
THERMAL PROPERTIES				
Max Svc Temp, F	600	1200	1600	1900
Linear Shrinkage, %[a]				
600 F	1	—	—	—
1200 F	—	1½	—	—
1500 F	—	—	1½	—
1900 F	—	—	—	2½
Ther Cond, Btu/hr/sq ft/°F/ft				
100 F	0.35	0.32	—	—
200 F	0.38	0.37	—	—
300 F	0.42	0.42	—	—
400 F	0.46	0.46	0.64	0.69
500 F	—	0.51	0.66	0.71
600 F	—	0.56	0.68	0.73
700 F	—	0.61	0.70	0.75
800 F	—	—	0.72	0.78

[a]Aged 24 hr.

cate and two types of diatomaceous silica insulations. The new data are offered as a basis for engineering calculations on these materials. The properties for all four products are given in the table above.

Waveguide Tubing Has Sharp Corners

Rectangular stainless steel tubing with extremely sharp corners and close dimensional tolerances is now available for use as waveguide tubing.

According to the producer, Superior Tube Co., Norristown, Pa., tolerances on inner dimensions are held to within 0.002 in. on some

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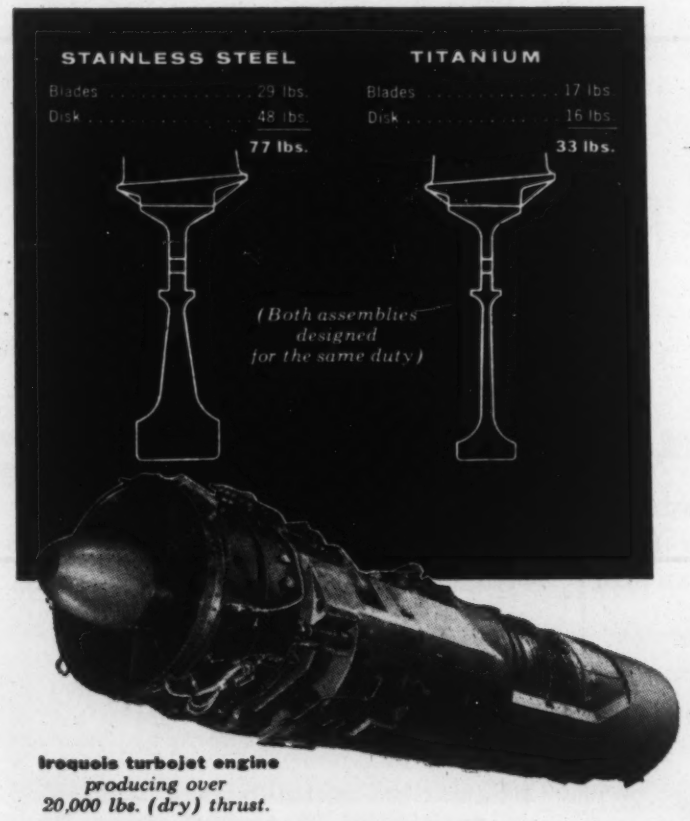
Canada's newest supersonic interceptor

In the Arrow's twin IROQUOIS turbojets...

TITANIUM CUTS WEIGHT 57%

in compressor blade assemblies



Iroquois turbojet engine
producing over 20,000 lbs. (dry) thrust.

Twin Orenda-built Iroquois jet engines will speed the Avro Arrow through space at 20 miles per minute. In these advanced design turbojets, as in the aircraft structure itself, every pound of weight-saving becomes a vital consideration.

To Orenda designers, titanium's high strength-to-weight ratio proved a double bonanza. By using titanium in place of stainless steel for compressor blading, much lighter titanium disks could also be used. *Result: A total weight saving in the assembly of 57%* (see diagram). In addition, lighter structural members could be used, contributing further weight savings and improving performance.

Mallory-Sharon, in cooperation with Atlas Titanium, Ltd., produced many of the titanium alloys which help make possible the Iroquois' superior performance. These same technical and production facilities are available to you *now* . . . to assist you in using titanium's outstanding physical and mechanical properties to maximum advantage. Write us for information or technical assistance.

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Exceptional metal-ceramic bond strength (withstands 4000 psi pull) combined with the outstanding physical and electrical stability of Centralab High Alumina—results in a product that can provide the solution to many of your military and commercial reliability problems.

Centralab's 30 years' experience in engineered ceramics, plus newly expanded production facilities, provide a fast, dependable source for High Alumina and Steatite ceramics. These can be supplied with or without metalized surfaces.

Write for the new Centralab Engineered Ceramic Design Catalog 42-221 or consult Sweet's Product Design File (folio 4 a/ce).

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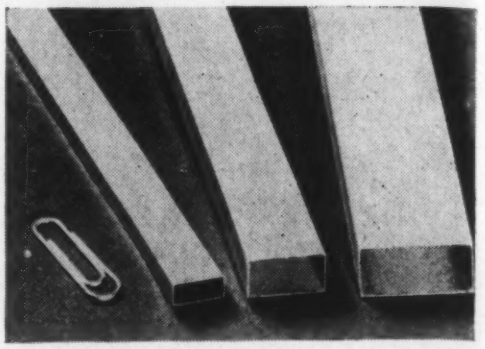
What's new IN MATERIALS



Rectangular tubing, *supplied in a variety of sizes, is used for waveguide applications.*

sizes; these tolerances are said to be much closer than in present commercial specifications. The sharp radii, down to 1/64 in. in smaller sizes, is said to permit critical waveguide dimensions to be held in the corners of the rectangular tubing.

Made from nonmagnetic type 304 stainless steel, the tubing is now being used for microwave paramagnetic resonance experiments at high and low temperatures. These experiments are used to determine crystal structure of solids, molecular structure and interatomic forces. The stainless steel waveguide tubing is expected to find use in radar installations where its good corrosion resistant properties are advantageous, such as in marine atmospheres.

The tubing is produced with inside dimensions from 0.122 x 0.061 in. to 1.872 x 0.872 in.; wall thicknesses are from 0.010 to 0.025 in. The tubing is supplied in 5-ft lengths.

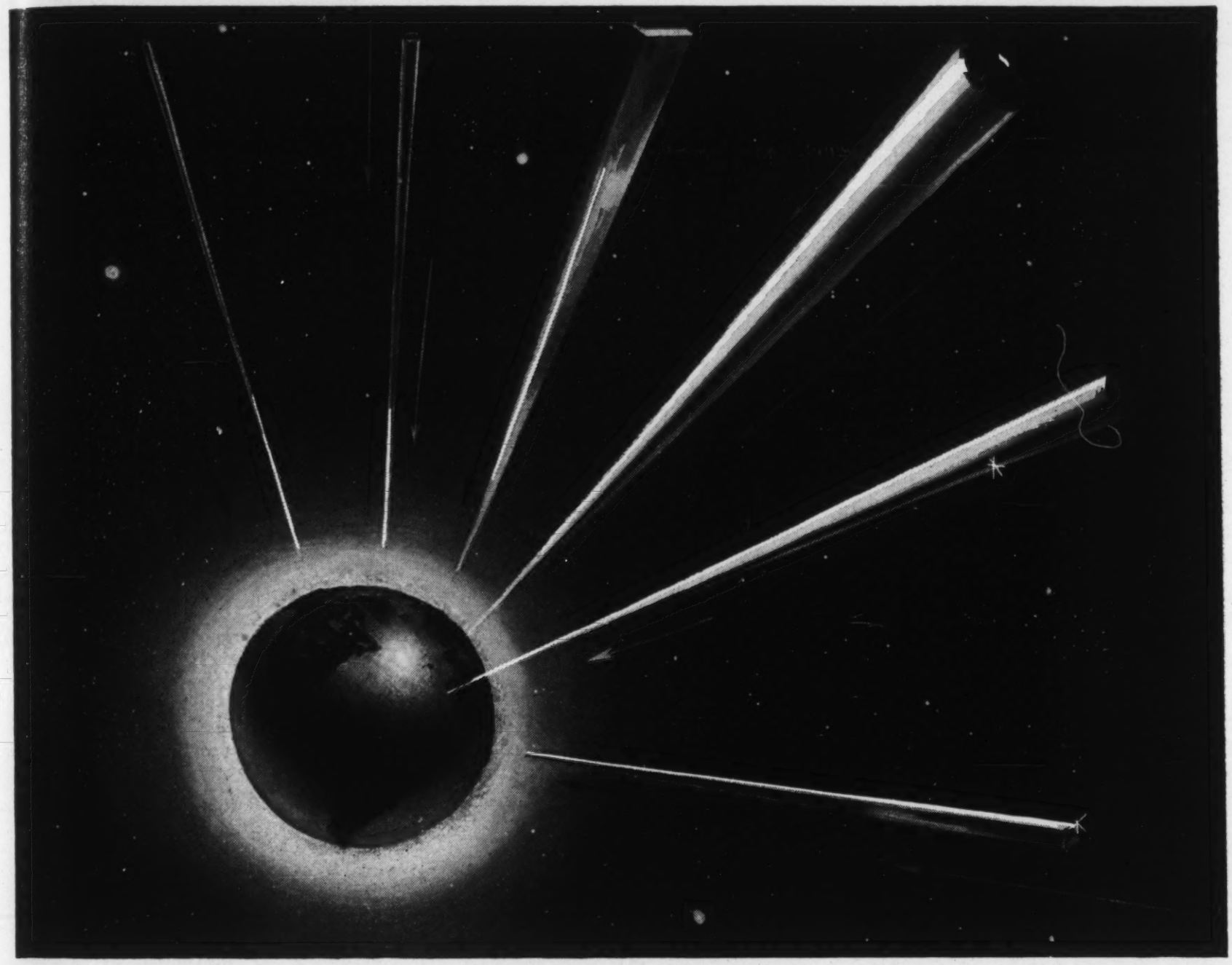
In addition to type 304 stainless steel Superior can produce rectangular tubing to waveguide tolerances from carbon and alloy steels, nickel and nickel alloys, and beryllium copper.

Other News . . .

Metals

▸ Samarium metal is now available in purities of 98 to 99% from Research Chemicals, Inc., Div. of Nuclear Corp. of America, 170 W. Providencia St., Burbank, Calif. The high cross section of the rare earth metal, 5500 barns, makes it particularly useful in nuclear reactors.

▸ Brass-plated steel sheets in 24 and 32-in. widths are being marketed by



Let's get down to earth about Exotic Metals!

Do you think titanium, zirconium, columbium, tantalum and other exotic metals are "out of this world" for your use?

You may be mistaken. Today the picture is changing. Increased demand and new production techniques are fast bringing their cost and availability *down to earth* for many commercial applications.

In fact, many companies are finding that their use often more than compensates for their extra cost in unparalleled corrosion resistance at high temperatures, better performance and longer service life.

If you have special problems of heat or corrosion resistance...a difficult application that demands unusual mechanical, physical, structural or nuclear properties...these metals deserve careful consideration. And Bridgeport is ready to help you use them.

LOOK INTO THE BRIDGEPORT METALS DEVELOPMENT PLAN

Bridgeport has pioneered in fabricating mill products from exotic metals from the start and has produced many miles of special metals tubes. We have originated many of the processing methods that are daily transforming these metals from costly rarities to readily available materials in a variety of forms—tube, rod, sheet and extruded shapes. This represents a substantial investment in time, skill and equipment. Because of our confidence in the rapid progress of exotic metals technology, we are prepared to work with you in their application on a cooperative basis. We welcome the opportunity to help solve your most difficult application problems. The coupon will bring prompt action. Send it today.

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Please send information on the BRIDGEPORT SPECIAL METALS DEVELOPMENT PLAN.

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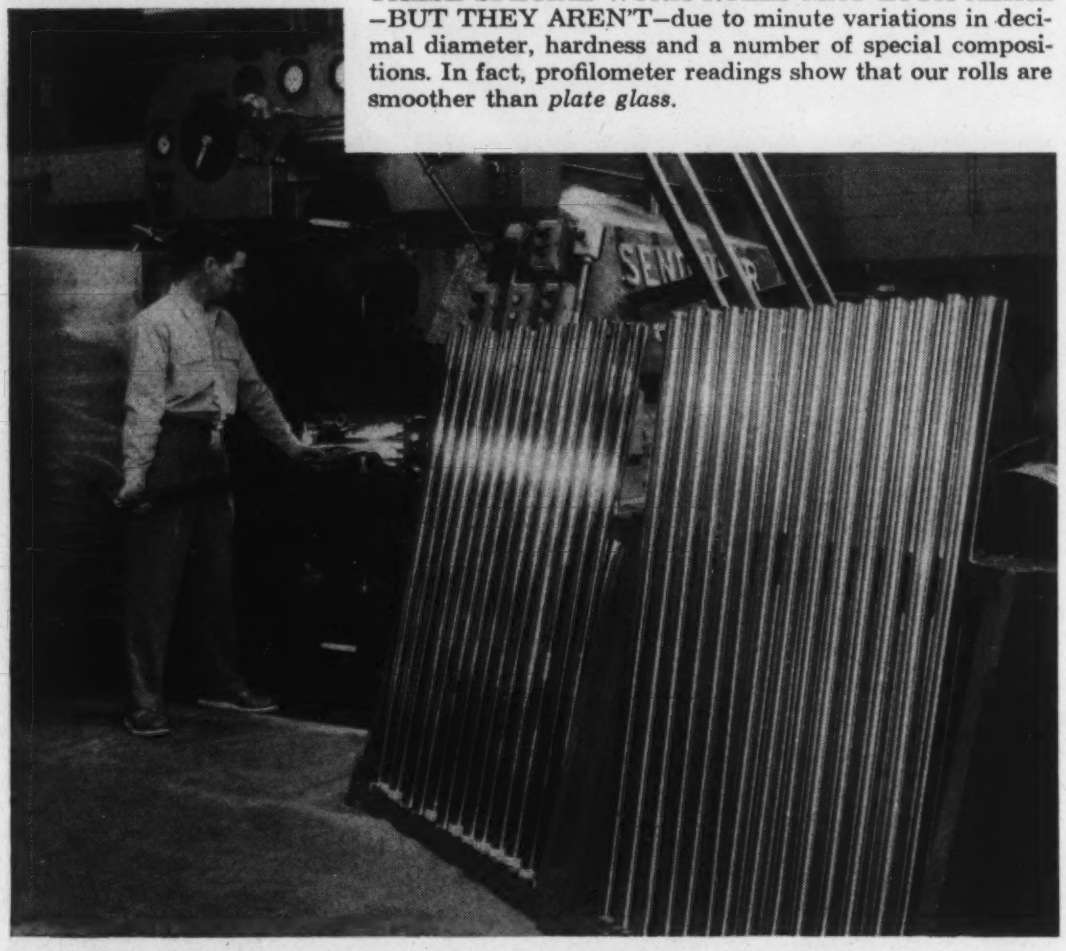
OUR SENDZIMIR MILLS produce sheets up to 48" wide, in thicknesses from .010" to .109", and .005" to .109" in 36" wide sheets in all commercial grades, finishes and tempers. Strip is available in gauges from .0015" to .090".

THESE SPECIAL WORK ROLLS MAY LOOK ALIKE –BUT THEY AREN'T–due to minute variations in decimal diameter, hardness and a number of special compositions. In fact, profilometer readings show that our rolls are smoother than *plate glass*.



It takes more than just a precision mill to produce

STAINLESS STEEL *of* MicroRold® *quality*

. . . it takes Operating Know-How. Only Washington Steel, *first to use Sendzimir sheet rolling, can offer you 10 years of practical experience with these mills.*

Every hot-rolled stainless steel band has variations in thickness and surface characteristics which must be compensated for in the cold-reduction process to obtain precise gauge and flawless surfaces. To do this, special work rolls with minute diameter differences along the length of the roll are used in controlling such variations as crown, edge and camber. To accurately control all the possible variations requires a large number of these rolls, plus *highly skilled operators* who know from experience which rolls, speeds and reductions are required. These are but a few of important factors in quality rolling which can only be learned by *long* experience and association with precision mills.

Washington Steel is the only producer whose entire production stainless steel sheet and strip is rolled exclusively on the Sendzimir Mill.

WASHINGTON STEEL CORPORATION

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What's new IN MATERIALS

American Nickeloid Co., 2nd & West Sts., Peru, Ill. The brass electroplate is said to be heavier than on previously available brass-plated steel sheets.

▸ Cold drawn steel bars with superior brightness are now available from Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30. Known as Bright-Drawn, the bars are supplied in rounds from 1/16 to 4 in. in dia; in hexagon shapes ⅛ to 3 1/16 in. in dia; in squares ⅛ to 4 in. in dia; and in flats up to 6 in. in width.

Nonmetallics

▸ A ceramic encapsulating material for electronic parts has been developed for use at temperatures from –70 to 2000 F. Called Eccoceram, the material has a flexural strength of 1000 psi and a dielectric strength of 100 v per mil. The producer is Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.

▸ A sponge rubber stripping material called Reinforced Rub-R-Shim contains a specially developed material that is said to prevent stretch, thus eliminating all post application tendencies to pull away from irregular corners and curved surfaces. The stripping is marketed by Johns-Manville Corp., Dutch Brand Div., 7800 S. Woodlawn Ave., Chicago 19.

▸ Fiberglass-reinforced polyethylene film has been introduced by Owens-Corning Fiberglas Corp., Industrial Div., 16 E. 56th St., New York 22. Sold under the brand name "FRF," the reinforced film is said to have improved strength and tear resistance and less tendency to stretch, bag and billow than conventional polyethylene film.

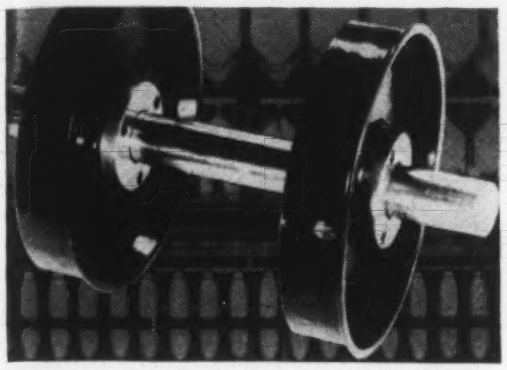
Finishes

▸ A nickel-manganese electrode has been developed for hard surfacing manganese and carbon steel castings and forgings. The electrode, designated Walmang No. 3 and available from Wall Colmonoy Corp., 19345 John R St., Detroit 3, produces a deposit with a hardness of 229 Bhn.

▸ A nickel-base hard facing powder containing tungsten carbide and chromium borides is available from Wall Colmonoy Corp., 19345 John R St., Detroit 3. Named Colmonoy No. 75, the powder is recommended for applications requiring exceptional resistance to abrasion and galling.

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **impact strength comes down in price**
- **fast-curing phenolic cures a cost problem**
- **new idea for closures**



High impact at low cost

These big pulleys help drive huge spinning frames made by Roberts Co., Sanford, N. C., a leading manufacturer of textile machinery.

Until recently, the pulleys were made of stamped metal or heavy cast iron. Designers looked for a better material—strong, dimensionally stable, low in cost. They found it in *Durez 18683*.

This new sisal-filled phenolic solves the cost problem of high-impact parts in three ways:

1. It costs only pennies more than general-purpose wood-flour-filled phenolics.
2. It molds by simple compression or transfer methods, using standard presses, standard pressures, standard dies.
3. It cures as fast as general-purpose compounds.

Durez 18683 molds dimensionally stable parts with impact strength of 1.4 ft. lb./in. Molded parts are self-extinguishing, have excellent resistance to humidity, and can meet U/L requirements for attached electrical contacts. You'll find that *18683* opens the way to savings on hundreds of applications where higher-cost materials are used now.

Consider it for heater and air-conditioner housings, instrument panels. Specify it for gears, wheels, pulleys, electric motor end bells—wherever you need impact strength and want it at lower cost.

The sooner you investigate *Durez 18683*, the sooner you can start saving with it! For bulletin, data sheet and/or evaluation sample, mail the coupon today.

Torrid tempo

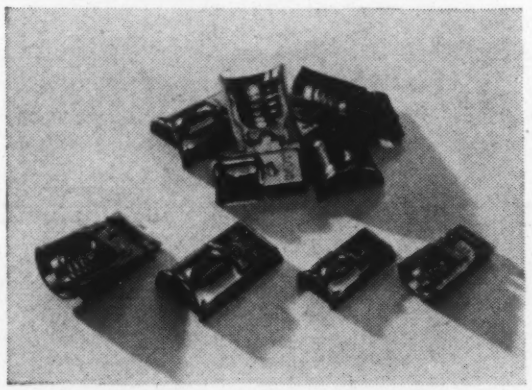
Rapid production is beating out a new rhythm of lowered costs for the makers of these small lamp sockets (center column), Noma Lites, Inc.

The key notes are smart redesign, use of multi-cavity molds, and an exceptionally fast-curing Durez phenolic.

Formerly, the manufacturer bought one-piece sockets, forced metal screw shells into them, applied pitch to protect against moisture, then laboriously soldered in the wires.

Zip! Now, threads are molded into the split sockets by the molder, Holyoke Plastics Company Inc. Wires are laid across the socket halves. A simple metal clip joins the halves and pierces the wires with contacts.

Whoosh! Socket halves are molded 80 at a time. Into the molds goes speedy *Durez 265,* general-purpose compound that cures in a few seconds. Even at this dizzy rate, its batch-to-batch uniformity assures consistent molding.



Hurry! Want to snap things up a bit? *Durez 265* can probably help you do it. To see how, dash right over to your molders. Or shoot us coupon for data on *265* and other GP molding compounds.

A cap can be pretty

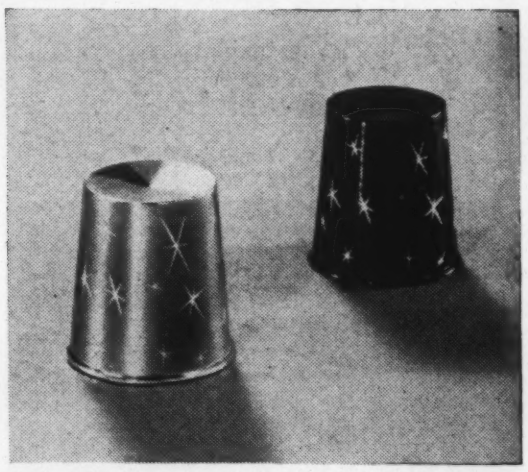
Not so long ago, you couldn't get this decorative effect in a molded plastic closure. Now you can.

It's done by wiping color into the debossed design. Debossing used to be the crux of the problem, because of the undercuts. It was impossible to make a workable mold cavity by machining, hobbing, or casting.

The solution: electroforming. The mold is built up in nickel around a soft, resilient master, which is then withdrawn from the cavity.

The process is a development of Armstrong Cork Company and Electromold Corporation. It gives the designer a new freedom—permits intricate textured effects like leather and wood grain, as well as the simpler ones you see here.

Durez is in the picture, too. Versatile phenolics, especially formulated for bottle and container caps, provide the requisite impact strength, resist chipping and cracking, and do not bleed when in contact with alcohol. If these qualities might help you uncork a closure idea or unbottle a bottleneck, we suggest you contact your molder on the use of Durez phenolics for closures.



For more information on Durez materials mentioned above, check here:

- ☐ High-impact low-cost phenolic, *Durez 18683* Bulletin and data sheet
- ☐ Evaluation sample of *Durez 18683*
- ☐ *Durez 265* (data sheet) and descriptive Bulletin 400

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

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Add 7% Copper
40,500 PSI Tensil
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MATERIALS AT WORK

Bridges—cont'd from p 12

The concrete deck is tied securely to the aluminum girders with aluminum shear connectors to achieve a composite action. Advantages claimed for the aluminum bridge are: light weight, ease of erection, and elimination of maintenance.

The bridge, built by Pullman-Standard Car Mfg. Co. and sponsored jointly by the State of Iowa, Aluminum Co. of America, Kaiser Aluminum & Chemical Corp. and Reynolds Metals Corp., was developed to "stimulate broader use of aluminum in the nation's huge highway program."

Arch bridge

The experimental arch bridge, designed by Georgio Baroni and sponsored by Reynolds Metals Co., is said to offer these advantages: light weight, ease of erection, elimination of maintenance and low initial cost (although aluminum is about four times as expensive as steel, the aluminum structure weighs about one-fourth as much as a comparable steel bridge).

The bridge consists of prefabricated parabolic arches stiffened by welded diaphragms. The ⅛-in. thick, 4-ft wide arches are joined side to side to form a continuous roadbed of any desired width. Bridge sections between piers can be over 100 ft long. According to Reynolds, the aluminum parabolic arches give the bridge an excellent strength-weight ratio. Alloy 5083 aluminum sheet is used for the arches and most other components.

The prototype bridge was thoroughly tested at New York University; 70,000-lb loads were applied every 3 sec for a total time equivalent to 100 years of service. The first application is expected to be a 234-ft highway bridge in Alabama.

***Positioning** parabolic arch section.*

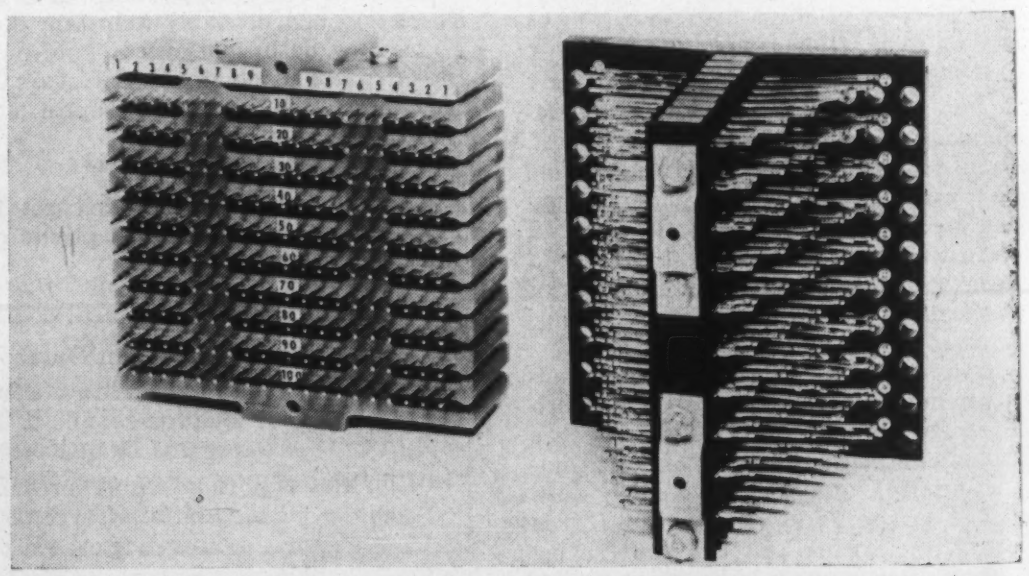
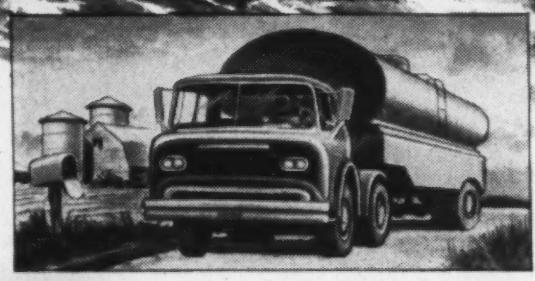


***Fig 1**—Contacts on epoxy terminal (left) are neat, require no soldering; old phenolic terminal (right) takes four times as long to install.*

Redesigned Terminal Turns to Epoxy

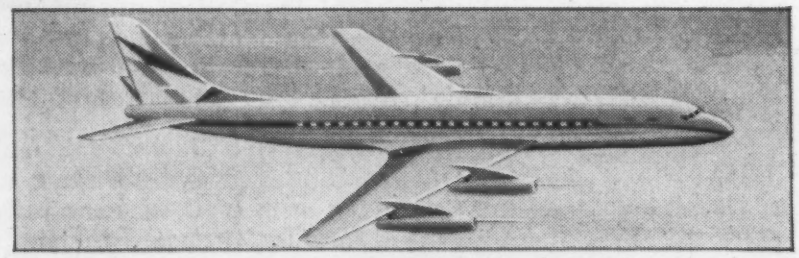
The switch from phenolic to epoxy resin, together with a redesign, has resulted in improved electrical and mechanical properties as well as a reduction in cost of a terminal block —even though the epoxy resin is

The steel plowshare was the basic agricultural tool when Wyman-Gordon was established seventy-five years ago. At that time, it took approximately 50 per cent of the nation's work force on farms to produce food for our country's needs.



With today's mechanical farm implements, it requires only 12½ per cent to feed our people. The development of modern farm implements, motor cars, trucks and tractors, railroad locomotives, and the "Mach era" aircraft and space vehicles, would have been impossible without forgings.

Whenever the ultimate is required in power, speed, endurance or reliability there is no substitute for a forging. Today, as for seventy-five years, Wyman-Gordon continues in the forefront in new forging developments.



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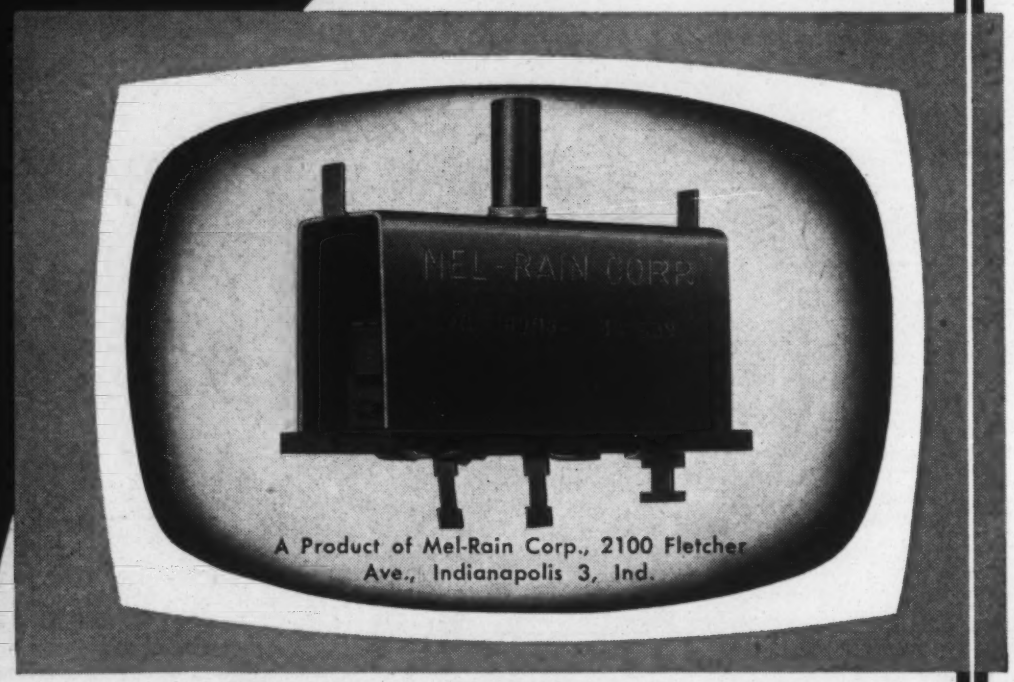
Chace Thermostatic Bimetal

ACTUATES ANOTHER PRECISION PRODUCT . . .

THE MEL-RAIN TV CIRCUIT PROTECTOR



While all will agree that TV circuits need protection against malfunctioning, especially for conditions which could start fires, the nuisance and high cost of fuse replacement by a service man is abominated by all. Mel-Rain Corporation has licked this problem with their line of TV Circuit Protectors. They make the set inoperative in case a hazardous condition exists but, since a high percentage of failures is due to ageing or intermittent surges, the set may be put into use immediately by simply resetting the button. The Mel-Rain design also prevents "cycling" and sticking of contacts, and the breaking of the circuit by high ambient temperatures both in the set and in the room. The units are low-cost, reliable and handle a current range from 100 MA to 7½ amperes in a temperature spread up to 150°.

Here is a case where *reliability* in the protective device must be obtained at low cost, as competition is severe among TV manufacturers. Known for a third of a century for its dependability and precision, Chace Thermostatic Bimetal is also far and away the best *buy* in bimetal. The quality which results from Chace's processes reduces rejects to an almost incalculable fraction of a percentage point, an indication of the skill of our manufacturing and the thoroughness of our development, testing, and inspection methods. Final proof, of course, is the satisfaction which products actuated by Chace bimetal give to their owners, year after year.

When your temperature responsive device approaches the design stage, remember these qualities of over 30 types of Chace Thermostatic Bimetal, whether in strip, coil or completely fabricated elements of your design. Send for our new booklet, "Successful Applications of Chace Thermostatic Bimetal," containing many pages of design data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service Card, circle No. 412

AT WORK

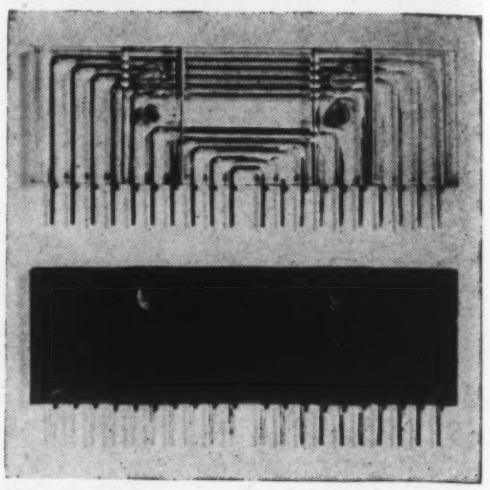


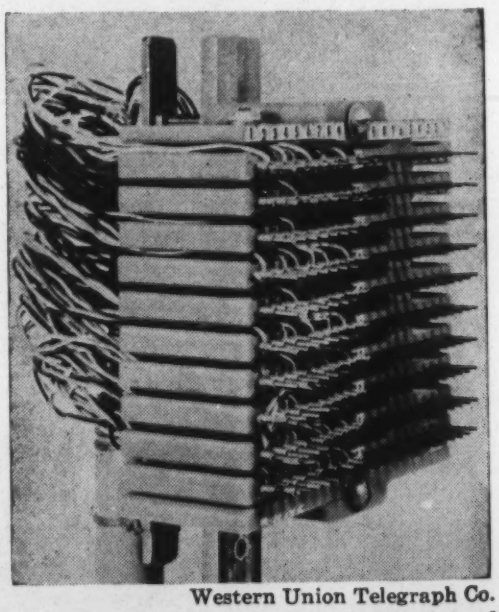
***Fig 2**—Epoxy resin terminal blocks. Transparent unit shows how conductors are arranged.*

more expensive.

The old phenolic units (see Fig 1) had two faces, required soldering of individual terminations and were relatively inflexible. The new design consists of a gang of individual terminal blocks, each containing ten U-shaped conductors (see Fig 2). All wire terminations are on one single and easily accessible face; thus the unit can be installed before connections are made and connections can be changed readily with the block in place. Moreover, connections are made with a wire-wrap terminating tool, thus eliminating costly individual wire soldering (see Fig 3).

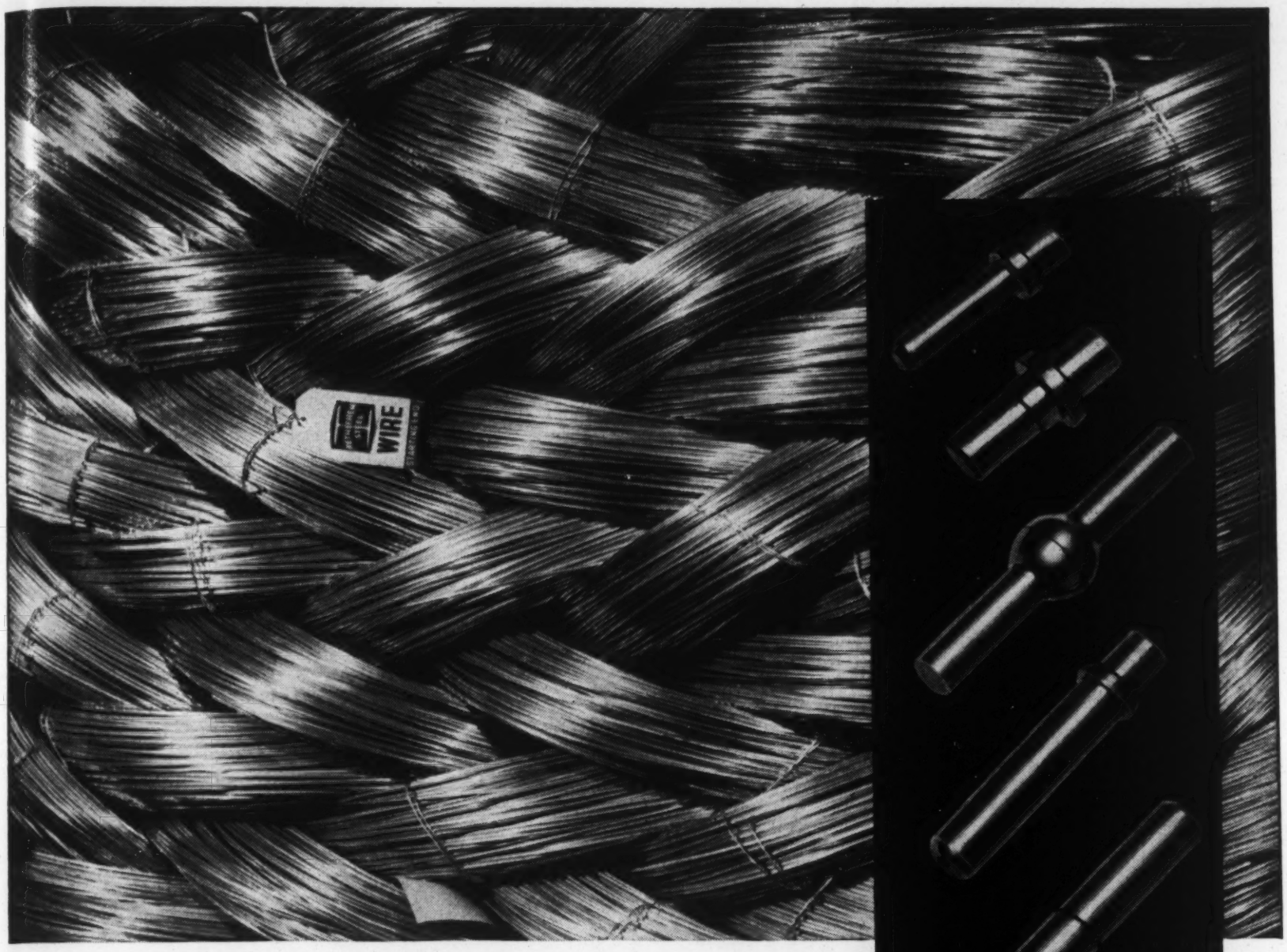
Cast polyester tried

Original planning for the redesign called for casting the terminal blocks with a filled glass-reinforced poly-



Western Union Telegraph Co.

***Fig 3**—Close-up of partially wired epoxy terminal.*



How to be sure you're using the right cold-heading wire

It pays to be fussy about the grade of cold-heading wire you use in operations like upsetting, forging or roll-threading. The job is half licked when you start with the correct type of steel wire.

Steel wire for cold-heading is a Bethlehem specialty. There are many ways in which our experience might prove helpful in bettering your production of cold-headed items.

At your invitation we will gladly study your products, equipment and process . . . and recommend the grade of steel that will perform the best. Then we'll carefully produce the steel to meet your needs.

Bethlehem cold-heading-quality wire is made to rigid standards. It is uniform in analysis and free from injurious surface defects. Thorough inspection at every stage of production typifies the quality-control that's behind every ton we ship.

One of our technical men will be glad to discuss cold-heading with you—or any other application of steel wire. Bethlehem makes nearly all kinds of steel wire. Just phone the nearest Bethlehem sales office, or drop a line to the address below.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 445

achieved by GOOD DESIGN

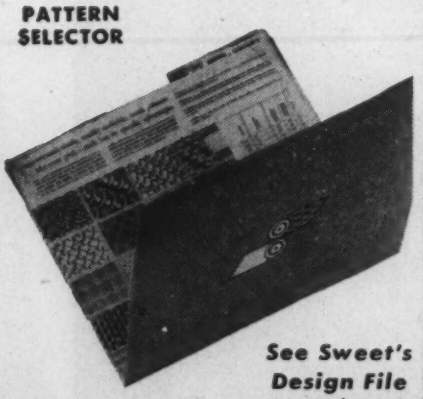
and RIGID-tex METAL®

The Helicopter cabin floor unit shown above was fabricated of aluminum 2024-T3 Rigid-tex Metal, Pattern 6-WL. By using RIGID-tex Metal for this unit the number of stiffeners to support the floor were minimized resulting in a considerably stronger unit and one with less weight than when made of plain metal.

Whenever you are asked to make a product stronger without increasing weight, remember RIGID-tex Metal, the original design-strengthened, three-dimensional metal that is stronger in all directions than flat-rolled, or coined metal.

Let RIGID-tex Metal help you also to achieve more beautiful designs with more eye and sales appeal. There are over 40 standard patterns from which to choose — in all metals — all colors. Let us send you literature and samples!

PATTERN SELECTOR



See Sweet's Design File 1f/Ri

Tell me more about RIGID-tex Metal...

☐ Send a copy of "Pattern Selector" showing all the standard patterns

☐ Send a sample of RIGID-tex Metal

☐ Send name of nearest distributor

*Name*_____

*Address*_____

*City*_____ *State*_____

RIGIDIZED METALS CORPORATION

66012 OHIO STREET • BUFFALO, N. Y.

WORLD-WIDE DISTRIBUTION

For more information, turn to Reader Service card, circle No. 372

ester formulation. (Although it was recognized from the start that epoxy resin would provide superior electrical properties, polyester was specified because of its price advantage.) Casting was selected over conventional molding techniques in order to avoid the possibility of distorting the inserts and thereby causing shorts.

Most of the polyester panels gave good results in electrical tests. However, every one was found to be too brittle and to exhibit too much shrinkage. More glass was added to the formulation, but the added glass made the material highly viscous, and encapsulation became difficult. Attempts to plasticize the formulation resulted in inferior electrical properties and reduced strength.

Cast epoxy better

Epoxy was then reconsidered. Because of its relatively low shrinkage (as compared to polyester), it was left unfilled; however, a polyamide-type curing agent was used to add toughness and to minimize shrinkage.

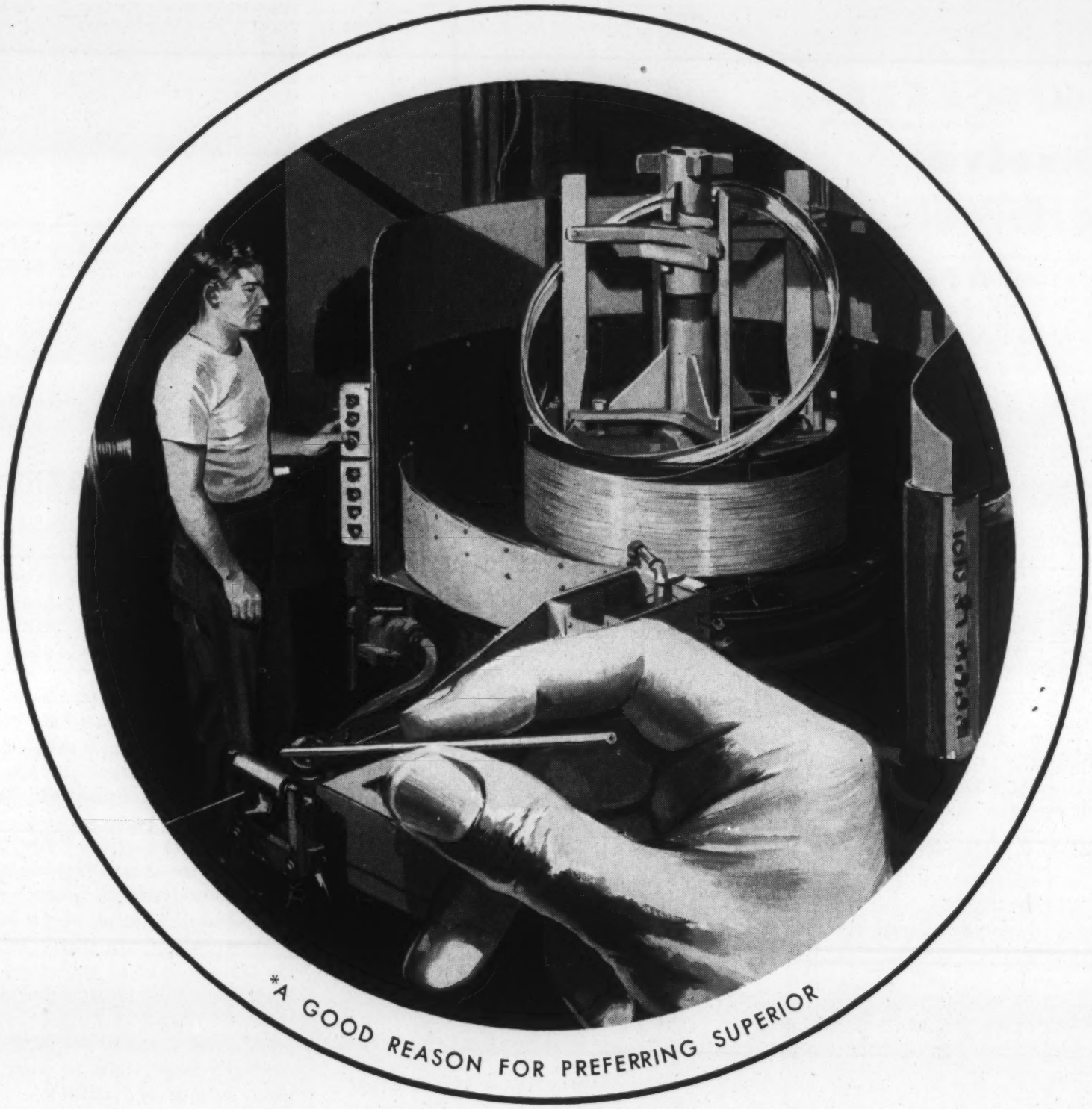
According to Smooth-On Mfg. Co., the epoxy terminal blocks offer the following advantages:

1. Improved dimensional stability.
2. Lower moisture absorption, resulting in higher surface resistivity under conditions of high humidity and elevated temperature.
3. Permanent toughness, superior flexibility and excellent strength.
4. Lighter weight.
5. Reductions in installation and maintenance costs.

Wire Thread Inserts Solve Design Problem

In order to meet rigid requirements of weight, size and accessibility in the design of mobile air conditioning equipment, a cast aluminum housing was specified instead of the ordinarily used cast iron housing. However, the use of the aluminum casting created an important design problem: the need for threads of higher loading strength and greater resistance to wear than aluminum possesses.

The necessity for a gastight seal eliminated the use of studs and



New—capillary tubing in 3000 ft. lengths for industrial instrumentation

Improved bore uniformity, broader size range, flow tested to your specifications

To meet the demands of modern instrument design and automated fabrication, Superior is now offering seamless capillary tubing in lengths up to 3000 ft. It is available in nine different materials from select-quality raw stock, including stainless steel, carbon steel, nickel and nickel alloy.

Scrupulous care in manufacture results in a finished product that is bright and scalefree, with an extremely smooth, uniform bore. The tubing is easy to weld, braze or solder. ODs range up to 3/16 in.—IDs from .004 to .040 in. maximum.

When you order capillary tubing by Superior you are assured that your specifications will be met. In addition to 100% dimensional, pressure and finish inspections, we also can test lengths for flow rates with the latest equipment when specified. Rates can be varied from 5 to 3700 cc per min.

More information on Superior's improved capillary tubing products is yours for the asking. Send coupon today.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. RAymond 3-1331

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Send me a copy of new Data Memorandum 11, on capillary tubing.

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 419

UNITCASTings solve difficult parts problem...

Foundry Engineering aids product development!

This steel casting is another example of Unitcast's ability to cope with unusual problems. As the main body of a new-type Pulsation Dampener for The National Supply Company's oil field equipment, this casting had many tough end-use requirements. Basically, the part had to absorb shock, withstand corrosion, and hold hydrostatic test pressures up to 8,000 psi. The fewer the components in the part, the better the durability.

The ideal solution, a one-piece steel casting, required accurate suspension of a huge core on a minimum number of points to produce a horizontal "tank" within consistent tolerances. One subsequent finishing problem involved economically "sealing" the core suspension holes by a method that would hold up in end use—*plus* pass radiographic inspection!

Once again, Unitcast foundry engineering has helped a customer develop a new product for their well-known line. Why not call in Unitcast engineers on your product-development problems? Write today!

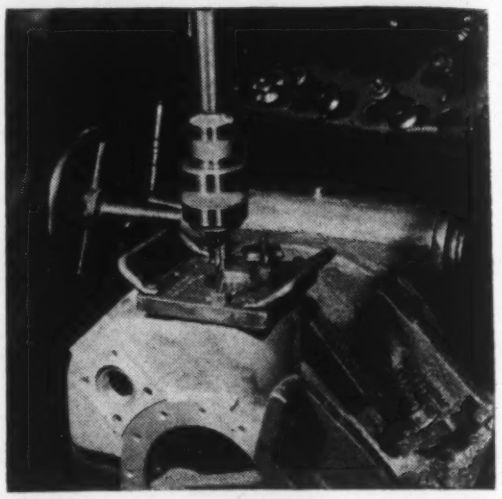
UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

For more information, turn to Reader Service card, circle No. 470



***Holes are drilled** to receive wire thread inserts.*

nuts. Solid thread bushings were found to be impractical because they require larger bosses and an increase in the gasket surface area, requiring a substantial design change in the basic casting.

According to Carrier Corp., stainless steel wire thread inserts, manufactured by Heli-Coil Corp., solved the problem. A total of 66 inserts in three sizes are used to provide threads said to withstand 40% higher loads than unprotected tapped threads of the same material. In addition, these threads are said to be practically impervious to wear, corrosion, seizing and galling.

To install the inserts, holes are first drilled through guide templates and threads are tapped; high speed pneumatic inserting tools are then used.

***Inserts are installed** with air-powered equipment.*

IT TAKES

LEAD

To Bury Radiation In Davy Jones' Locker *PERMANENTLY*

How do you handle a modern "hot potato"?

Tissue-destroying radioactive waste is, and in the foreseeable future will continue to be a really "hot potato." It is a major problem confronting the world's rapidly growing atomic energy program. By-product waste can't be left in the back yard for the trash man—a dog's buried bone method is out. To date, the best disposal method is enclosing it in lead and dumping it into the ocean. But even at 1,000 fathoms, this practice demands A SPECIAL KIND OF "WASTE BASKET."

DISPOSAL CONTAINERS OF LEAD

Why a *lead* container? Lead is plentiful, low in cost and is the densest of all commonly available metals. This uniform density makes Pb the most efficient shield against harmful radiation known today. It is practically imperishable. Fact is, the container will last longer than the high level radioactive life of its contents.

400 pound 5 curie "cobalt 60" container and plug manufactured by Reliance Foundry, Philadelphia 24, Pa.

ST. JOSEPH LEAD COMPANY

ST. JOE

250 Park Avenue
New York 17, New York

The Largest Producer of Lead In The United States

Pb-179

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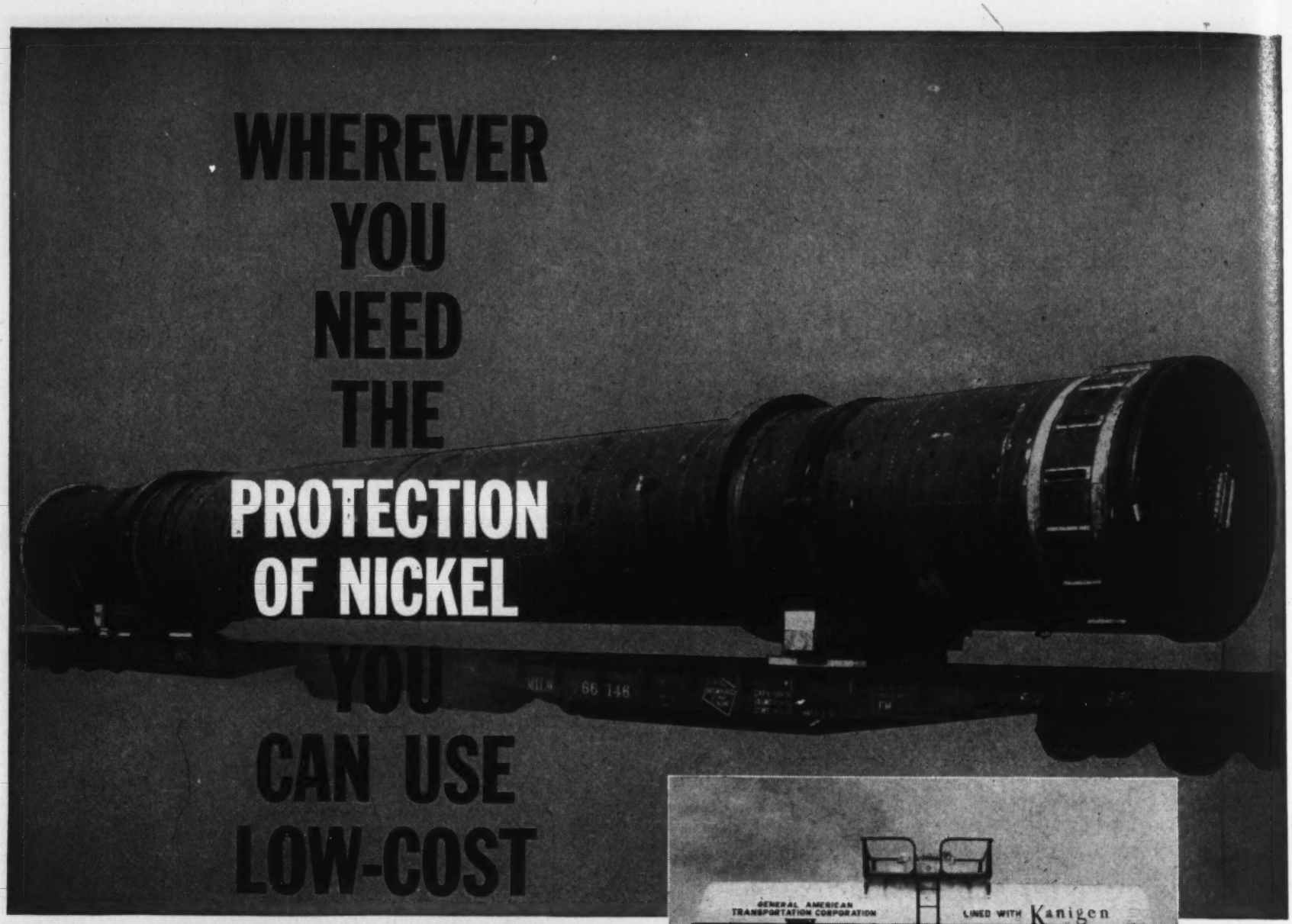


KANIGEN®

Kanigen® nickel-alloy coatings provide corrosion resistance and product contamination protection to process equipment.

With Kanigen—a hard, uniform, chemically-deposited coating—you can protect equipment of any size—from the interior of a huge dryer to a tiny pressure-relief valve.

This inexpensive nickel-alloy coating will do almost anything that nickel will do. Kanigen gives low-cost metals a hard, resistant nickel-alloy surface equal to or better than expensive alloys, solid metals or clad materials, at a fraction of the cost.

Your equipment or parts can be barrel-coated, rack-coated or jig-coated with Kanigen. General American has Kanigen plants at East Chicago, Indiana; Sharon, Pennsylvania, and Compton, California. Kanigen is also available from licensees in other parts of the country and abroad.

KANIGEN GENERAL AMERICAN TRADE MARK

KANIGEN *is a trademark which identifies chemical nickel coating by GENERAL AMERICAN TRANSPORTATION CORPORATION and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coatings.*

GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street • Chicago 90, Illinois

For more information, turn to Reader Service card, circle No. 488

PRICES AND SUPPLY

...AT A GLANCE

PHENOLIC RESIN PRICES HAVE BEEN REDUCED by Durez Plastics Div., Hooker Chemical Corp. The reductions, 2¢ per lb on four general purpose and two heat resistant phenolic compounds, and 1¢ per lb on four closure-type compounds, bring the prices down to 19½ and 20½¢ per lb, respectively. According to A. W. Hanmer, general sales manager, the reductions were made to help limit the number and variety of phenolic compounds presently being used. Almost simultaneously . . .

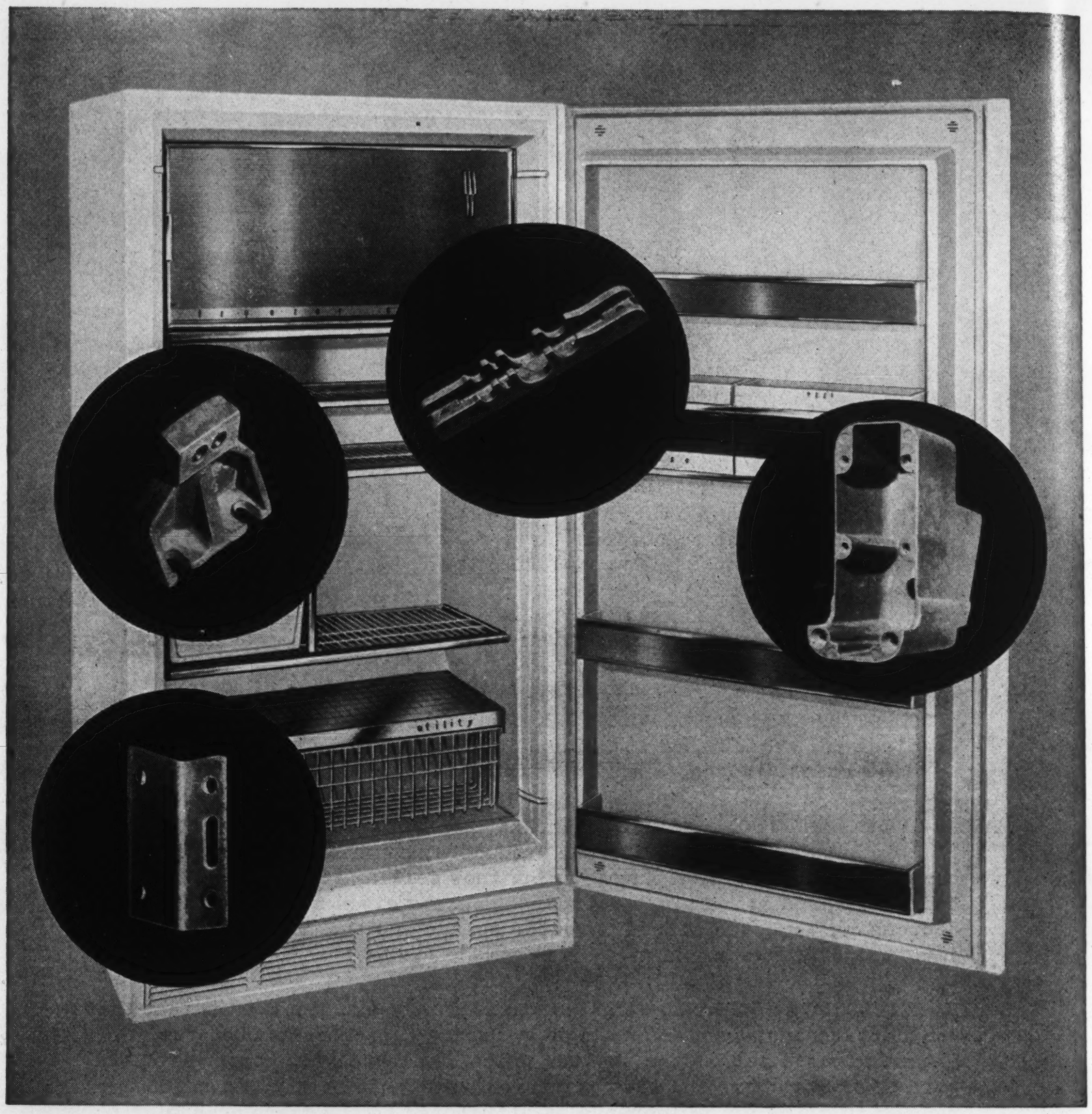
. . . PRODUCTION OF PHENOLIC MOLDING COMPOUNDS HAS BEEN STOPPED by Monsanto Chemical Co., which says it can use its facilities to better advantage in other areas. Monsanto will continue to produce other phenolic resins.

PRICES OF LEAD AND ZINC CONTINUE TO INCREASE. Lead, now available at 13¢ per lb from both custom smelters and producers, has been increased five consecutive times since Aug 15; zinc, now selling for 11¢ per lb, has been increased twice since October. Reasons given for price increases: decreasing domestic stocks, greater demand and the imposition of import quotas.

COPPER PRICES HAVE INCREASED SIX TIMES in as many weeks despite the fact that consumption increased only slightly during September and October. Latest figures put custom smelter price of electolytic copper at 28½¢ per lb, or 5½¢ above the low registered during the height of the '58 recession. The price increase is attributed to the sharp drop in production caused by the strikes in the Rhodesian copper belt and in Canada.

PRICE OF PLATINUM HAS BEEN REDUCED AGAIN to the lowest level since 1947. The new price is $57-60 per troy oz, down from $62-65 per oz. This latest reduction was the fourth this year and was said to be caused by a combination of decreased demand and reported lower-priced offerings from Russia.

INCREASED PRODUCTION OF SEAMLESS AND WELDED PIPE, tin plate, wire products, and strip mill products will result from Jones & Laughlin Steel Corp.'s recently completed $47-million continuous weld pipe mills at Aliquippa, Pa. According to the company, the mill is capable of producing welded pipe in a nominal size range of 1¼ to 4 in.



Kelvinator gets big benefits from premix moldings

Premix moldings are making an important contribution to performance of Kelvinator refrigerators.

Strike mounting plates, tie-straps, tubing retainers and lock housings for the Kelvinator are all premix moldings. They've proved tough and resilient . . . excellent shock absorbers. And their thermal insulating properties contribute to the economical operation of the refrigerator.

When resins and reinforcing fibers are blended beforehand, moldings are stronger, wall thicknesses more uniform, weak spots are eliminated. Small and large, simple and complex, premix moldings are not only improving products but cutting costs for hundreds of manufacturers.

If your product calls for strong, rigid, reinforced plastics, look into premix moldings made with Dow vinyltoluene or Dow styrene. Get the names of molders and suppliers from your nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, **Plastics Sales Dept. 2207G-2.**

YOU CAN DEPEND ON DOW

For more information, turn to Reader Service card, circle No. 367

Prices of Materials

Changes since last quarterly report in September are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.68	.46-.51
Butadiene-Styrene	.16-.30	.22-.32
Butyl	.22-.26	—
Neoprene[a]	.39-.75	.37-.47
Silicon[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural[b]	.29	—

[a]Less than carload quantities.
[b]Average spot price for month of Sept.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a]Price includes binder or finish.
[b]Price varies with binder.
[c]0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	.42	.32-.50
Silicon	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.40-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13	13	13	13
Nylon	1.18-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.25-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.25
Ingot (99-99.9%)	.27
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.28
Sheet (1100, 3003; 3-0.03 in.)[a]	.41-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.42-.45

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.45	.47	.48
Seamless Tubing	.48	.50	.51
Rod (not f.c.)	.45	.47	.48
Wire	.45	.48	.48

COPPER

Ingot (elec)	.27½
Sheet, Strip (hot rolled)	.51
Seamless Tubing	.51
Rod, Drawn	.48
Rod, Free Cutting	.59
Wire	
Round	.33
Square, Rectangular	.36
Magnet	.39

LEAD

Common Grade	.13

MAGNESIUM

Pig (98.8%)	.35-.36
Ingot (98.8%)	.36-.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN

Primary[a]	.96

[a]Delivered price.

(continued on p 170)

QUALITY BALLPOINT PEN DEPENDS ON UNIFORMITY OF 8 GRC "MATED" PARTS

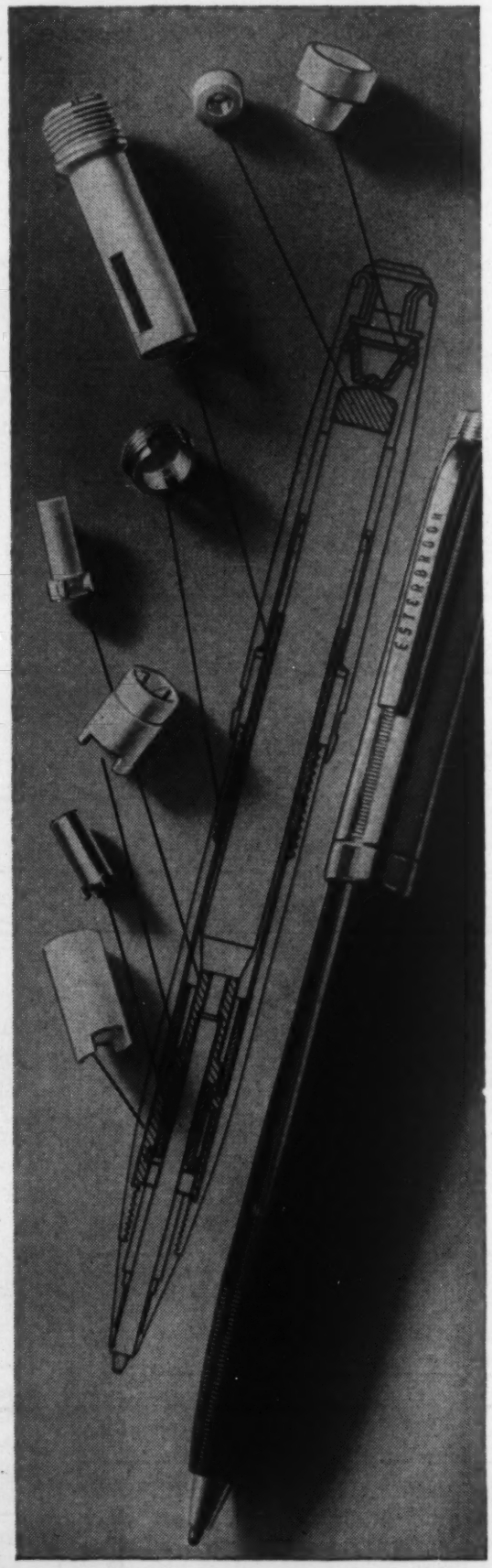
Die Cast and Molded Components Assure Trouble-Free Operation of Esterbrook's New Rotating Mechanism

GRC mass-production techniques have again provided a new dimension to designers faced with a difficult situation. Esterbrook engineers, realizing that most people pick up a pen repeatedly the same way, evolved a rotating mechanism to avoid wearing the ballpoint unevenly and to achieve better ink distribution. The intricate mechanism, however, presented a production problem. Parts had to be uniform, durable, meet close tolerances in order to assure proper mating of components and dependable functioning of the assembled pen.

GRC's exclusive patented methods for the precise automatic production of tiny parts solved the problem, and at lower costs. Gries molded five of the parts in duPont nylon, die cast two others in zinc alloy for strength and greatest economy. The eighth was Gries' nylon counterpart for an originally-scheduled screw machine part, produced for a fraction of the cost and more satisfactorily. These eight parts form the foundation of the mechanism for this new-type pen.

Uniformly accurate, clean, well within critical tolerances, these GRC die cast and molded parts eliminated the necessity of selective assembly and insure trouble-free operation by fitting mating parts exactly. Tests of the pen showed parts worked like new after the equivalent of more than a year's normal use, still worked smoothly after the equivalent of fifty years' hard use. (See illustration at left above.)

This high quality pen is typical of the new designs and cost saving economies possible through Gries' unique single cavity molding techniques and ingenious die casting methods. To find out how GRC can help you, write for their bulletins on tiny zinc alloy die castings and injection molded small plastic parts, or send prints for immediate quotations. There is no minimum size. Maximums are 1¾" long, ½ oz. in zinc alloy; 1¼" long, .03 oz. in plastic.



Write Today for Bulletins

WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

GRIES

GRIES REPRODUCER CORP.

153 Beechwood Ave. • New Rochelle, New York • NEw Rochelle 3-8600

For more information, turn to Reader Service card, circle No. 486

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	1.70-1.82
Bars, Rod	5.25-6.35
Plate	6.00-9.50
Sheet, Strip	8.50-15.95
Wire	6.50-11.50

ZINC

Prine Western	.11
Die Casting Alloys[a]	.14
Sheet	.24
Ribbon	.21
Plates	.19

[a]Alloys 2, 3, 5.

METAL POWDERS

Aluminum [a,b]	.39
Brass [a]	.31-.47
Copper (elec or red.)[a]	.42
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	3-4[c]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.45
Columbium	55-85
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34[a]
Palladium	$15-19/troy oz
Platinum	$59-60/troy oz
Silver	90-91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	80
Zirconium (sheet, strip, bar)	25-35

[a]Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	82
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

(continued on p 172)

For more information circle No. 456

try titanium now!

Now that there's a plentiful supply of titanium, all industry can benefit from its unique corrosion resistance. This property is combined with an unusually high strength-weight-ratio so that titanium works equally well in stationary and moving components, under vacuum or pressure.

But there may be even more compelling reasons for trying titanium now. Will its exceptional corrosion resistance mean new savings in maintenance? Will its ability to retain strength at high temperatures mean new production economies? Can titanium help you obtain increased product quality or yield?

There is only one way to ascertain what titanium can do for you. Try it now. You can't afford not to.

WHERE YOU CAN GET TITANIUM EQUIPMENT NOW!

Booklet tells where you can get titanium mill products and fabricated equipment. Also gives cost-saving service records in process industries.

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

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ELECTRO METALLURGICAL COMPANY ME-12
Division of Union Carbide Corporation
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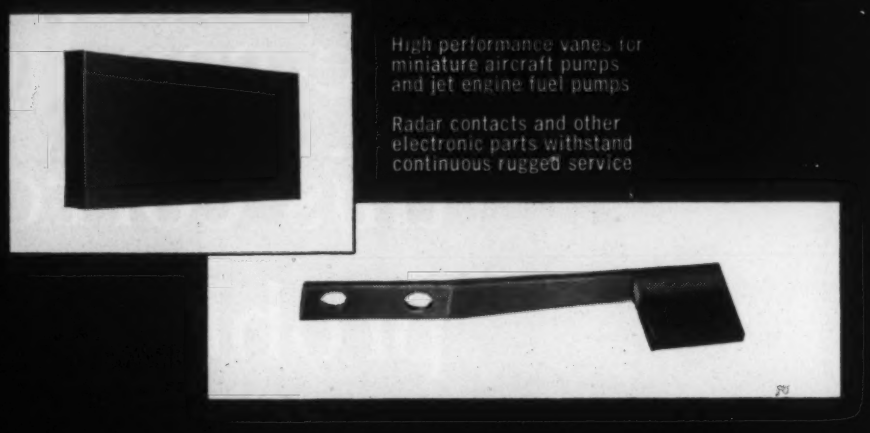
Please send me a copy of "New Heat on Titanium."

Name _____

Company _____

Address _____

New applications

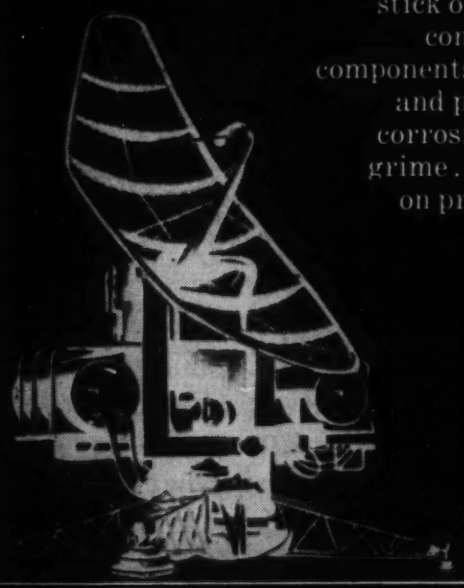


High performance vanes for miniature aircraft pumps and jet engine fuel pumps

Radar contacts and other electronic parts withstand continuous rugged service

–for self-lubricating MORGANITE

Morganite components provide complete reliability in many types of airborne equipment. Morganite will not warp, stick or gum, is self-lubricating, non-contaminating. These dependable components function in high temperature and pressures and are unaffected by corrosive chemicals, oil, water, gases, grime... the standard of performance on process equipment, compressors, meters, pipe line and general industrial machinery.



For trouble-free operation — Install Morganite bearings, seal noses, pistons, piston rings, rod packings, gland rings, slides, valves and special parts. Call or write today for recommendations on specific applications.

Morganite INCORPORATED ..FOR OVER HALF A CENTURY

3324 48th Avenue
Long Island City 1, N.Y.

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts.
Distributors of 99.7% Pure Al O Tubes and Crucibles

For more information, turn to Reader Service card, circle No. 426

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, H.R.	5.10	7.52	—
Sheet, C.R.	6.27	9.27	—
Strip, H.R.	5.10	7.57	8.40
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.67	8.30	6.72
Bar, C.F.	7.65	—	9.02

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.41-.46	.51-.55
321[a]	.47	.56	.55	.66
347[a]	.56	.65	.65	.80
Martensitic				
410[a]	.28	.34	.30	.40
416	.29	.34	.31	.48
403	.28	.34	.30	.40
420, 440	.34	.41	.40	.52
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.31-.32	.41-.47
442	.32	.38	.35	.56
431	.38	.44	.41	.56
446	.39	.44	.43	.70
High Mn				
202[a]	.37	.43	.40	.49
Extra Low C				
304L	.48	.56	.54	.63
316L	.70	.81	.80	.89
Precip Hard.				
17-7PH	.66	.73	.85	.90
PH 15-7 Mo	.86	.93	1.11	1.16

[a]Ingot price approx 60% of billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.36
Stainless Steel	
304	1.07
316	1.26

[a]Price for —100 mesh.

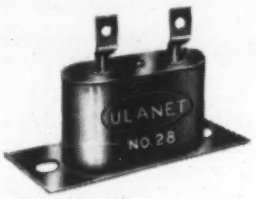
IRON ($/gross ton)

Pig	66-67

(continued on p 174)

YOU CAN PROFIT BY USING GENERAL PLATE CLAD METALS

Ulanet Thermostats Value Continued Material Uniformity in TRUFLEX parts and assemblies



Model 28 Miniature Hermetically Sealed Thermostat extremely sensitive.

Here's another case history of a leading manufacturer who has found he can depend on parts made from General Plate's TRUFLEX thermostat metal. H. Ulanet, President of the George Ulanet Company, puts it this way:

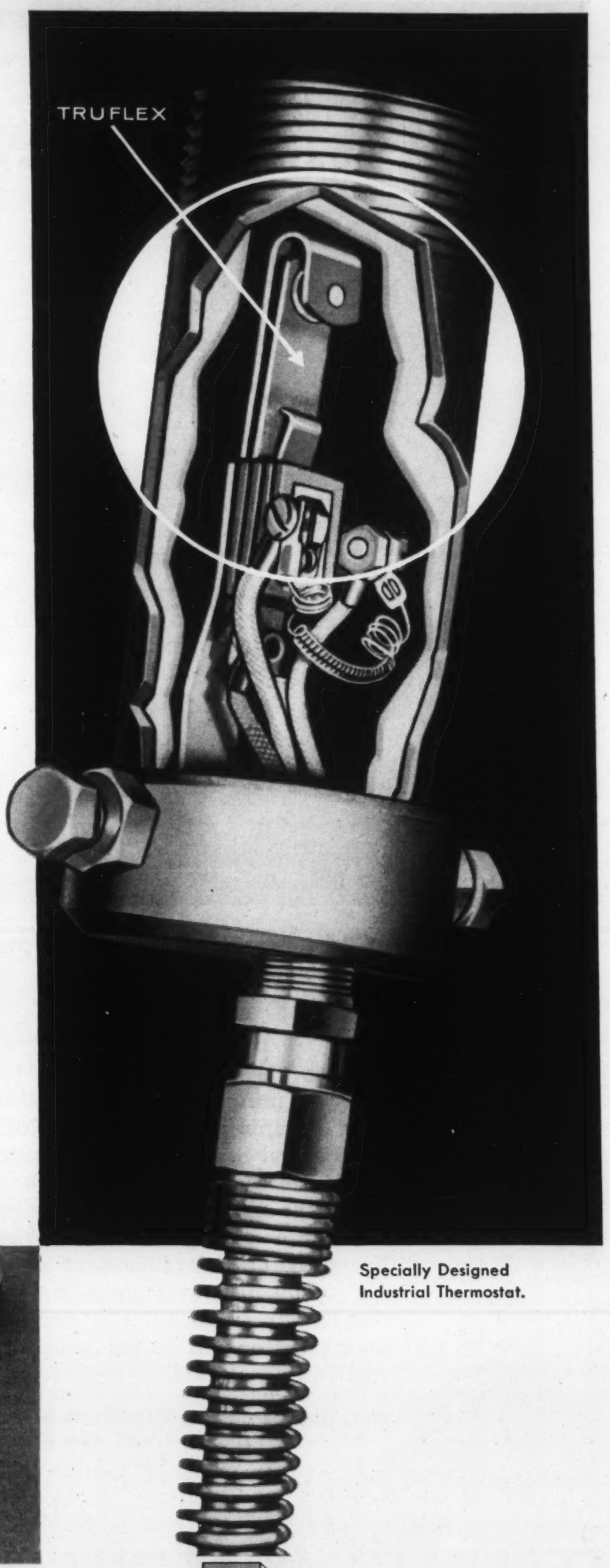
"Bimetal is a most important component in Ulanet Thermostats which have a world-wide reputation for quality. Therefore we must be certain of continued material uniformity and quality with each shipment.

"During our 22 years' experience with General Plate's TRUFLEX *thermostat metals we have found that they have met our exacting specifications."*

General Plate can supply dependable thermostat metal parts and assemblies for installation in your products, too. You'll get top performance because the high quality of each piece you receive is consistently uniform — an exact duplicate of the original.

General Plate TRUFLEX thermostat metal parts and assemblies are made to meet your specific needs for temperature range, electrical conductivity and corrosion resistance.

If you set up to make your own parts, General Plate can supply TRUFLEX thermostat metal strip to consistently meet your specifications. Send us your specifications for parts or strip — we'll be pleased to quote.



Specially Designed Industrial Thermostat.

A few typical Truflex formed parts and sub-assemblies.

You can profit by using General Plate Clad Metals!

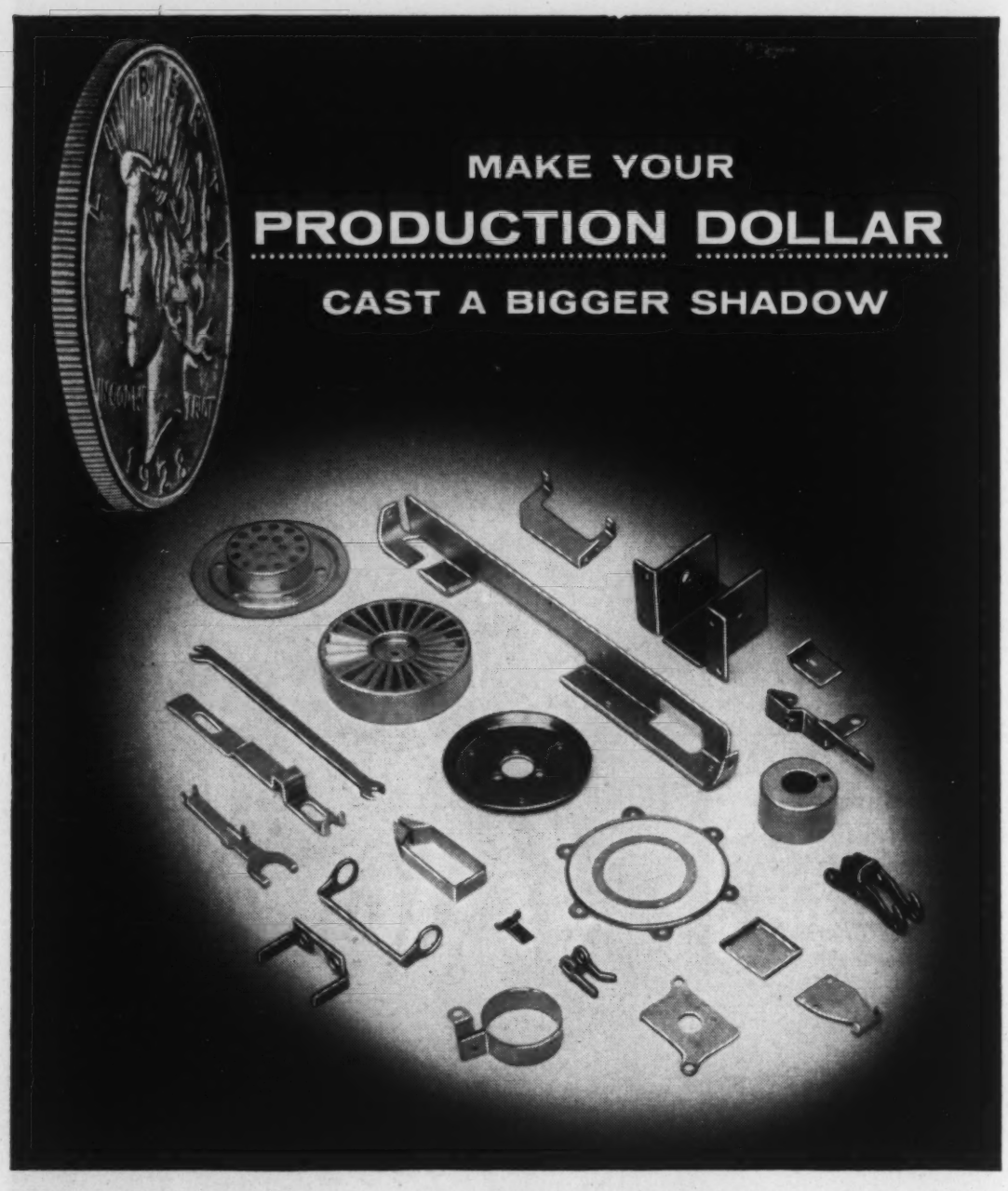
METALS & CONTROLS CORPORATION

General Plate Division

1612 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK • CHICAGO • DETROIT • INDIANAPOLIS • MILWAUKEE • PASADENA

For more information, turn to Reader Service card, circle No. 500



Federal Short Run Stampings may be your answer

Stretch your production tooling dollar up to 80% by using Federal "Controlled Tolerance" Short Run Stampings. That's the savings you get by using the Federal Stamping method instead of conventional tooling methods. You can *put a new product* on the market or make improvements in *existing products* with a *minimum tooling investment.* When quality, fast delivery and price are important factors, try Federal first for any quantity stampings from two pieces to 10,000. Size limitations are 10" x 14" and 3/8" in thickness. Send your print or part to the nearest plant for a Federal Analyzed Quotation.

Write for free Catalog 201. Tells how to reduce costs by using short run stampings . . . full of design tips.

QUALITY STAMPINGS
FEDERAL
IN SMALL QUANTITIES

3 PLANT LOCATIONS

FEDERAL TOOL & MANUFACTURING CO.
3652 Alabama Ave., Minneapolis 16, Minn.
FEDERAL SHORT RUN STAMPING, INC.
962 Lyell Avenue, Rochester 6, N.Y.
FEDERAL STAMPING COMPANY
7307 Atoll Ave., No. Hollywood, Calif.

For more information, turn to Reader Service card, circle No. 437

PRICES AND SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	29	32	34
304L	34	37	40
316L	47	51	56
321	35	38	41
347	41	45	49
430	23	26	28
Inconel	60	70	81
Nickel	52	62	73
Monel	54	64	74

[a]Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

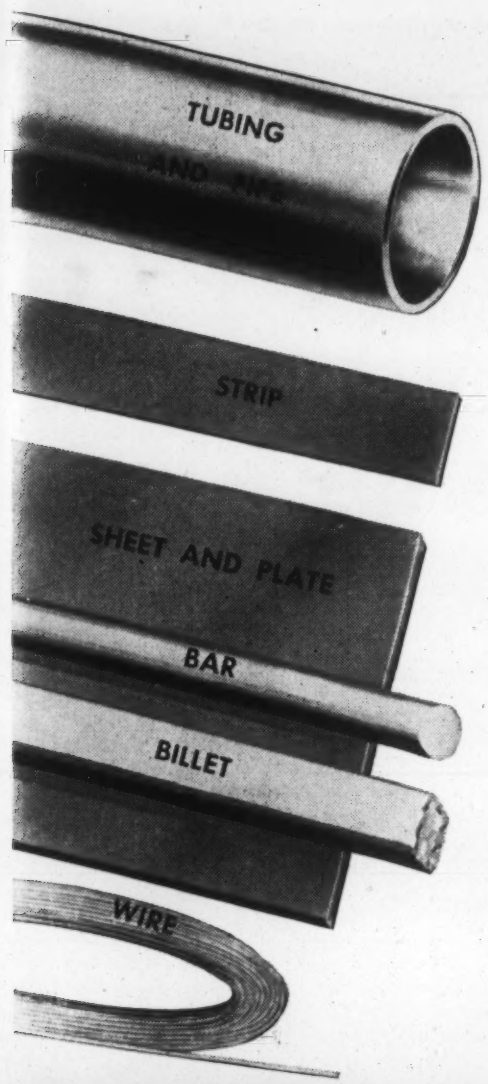
Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75- 9.40

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicon	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

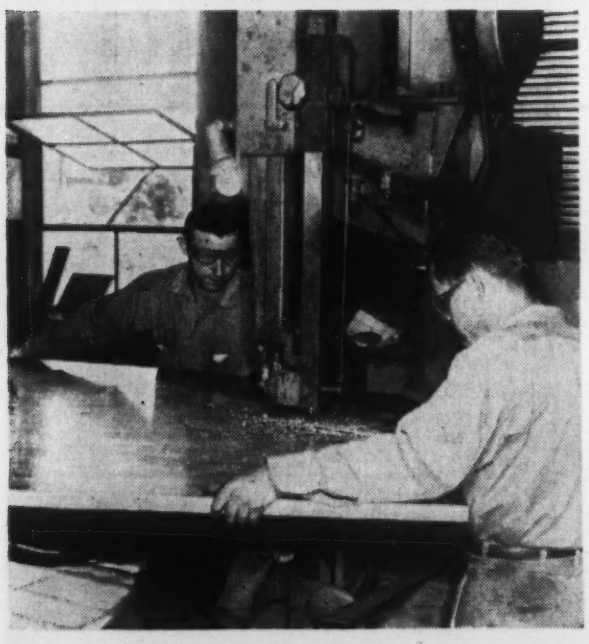
[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.



In-Stock Service

on Carpenter Stainless No. 20 and No. 20Cb

forms, sizes and shapes
for most corrosion problems



• Besides keeping our warehouses fully stocked with all forms of Carpenter Stainless No. 20 and 20Cb, we maintain fast, modern facilities to make up and speed your orders to you . . . no matter what your deadline. *Our service teams are geared to handle your most urgent delivery needs.*

Available from stock in sheet, plate, pipe, tubing, strip, bars, wire and billets, Carpenter Stainless No. 20 and 20Cb are as easily fabricated as ordinary stainless steels. You get long-life control of sulphuric acid and other severe corrodents in a hurry when you order Stainless No. 20 and 20Cb. One installation of this Super-Stainless will outlast most other corrosion-resistant alloys . . . economically. Contact our nearest office or authorized distributor (located in over 40 cities, coast to coast). Write on your company letterhead for technical bulletin 108A. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

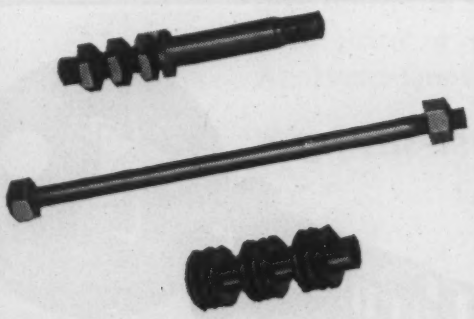
your master key to cost-saving corrosion control

Stainless No. 20 & 20Cb

Carpenter Stainless No. 20 bars, strip, wire and billets are available also from The Carpenter Steel Company, Reading, Pa.

For more information, turn to Reader Service card, circle No. 485

World's Biggest Eater Dines Without Interruption



Typical insulator and insulating bolts used on power shovels.

You are looking at 3 million dollars' worth of power shovel, a 14-story monster capable of biting off 70 cubic yards of dirt at a clip.

Continuous operation is essential because downtime on a shovel of this size could top 500 dollars an hour. Reliability is shared by many interrelated parts. Some are made of Synthane laminated plastics.

Why Synthane? Because Synthane laminated plastics have the right combination of properties—dielectric strength, mechanical strength, and ease of machining. And Synthane uses only first-quality raw materials, watches every step in the production and fabrication of the laminate, is deeply concerned about delivery requirements.

Good materials, competent people, excellent tools and workmanship may not guarantee reliability but they're strong assurance of it.

If you are interested in a reliable source of laminated plastics—sheets, rods, tubes, or completely fabricated parts, write for an interesting catalog or call our representative near you.

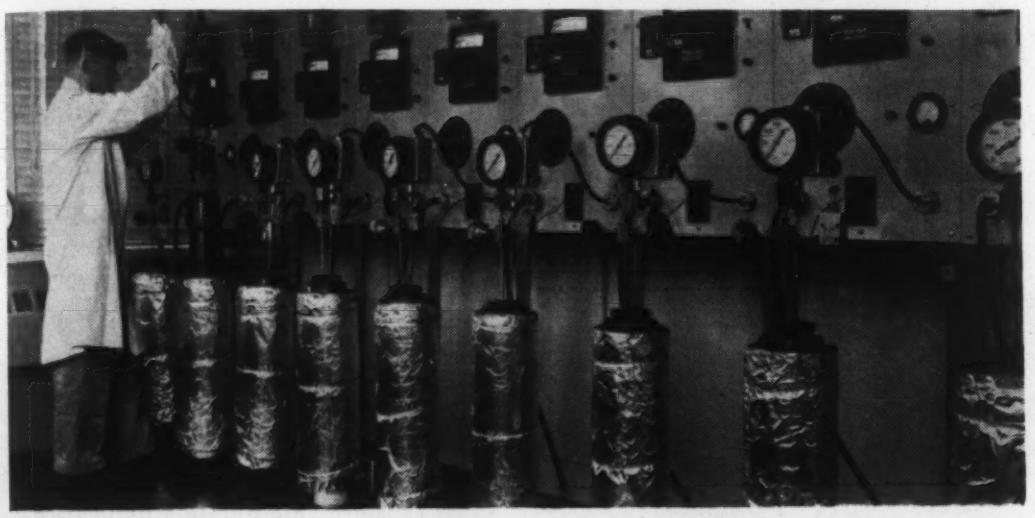
SYNTHANE

SYNTHANE CORPORATION, 3 RIVER RD., OAKS, PA.

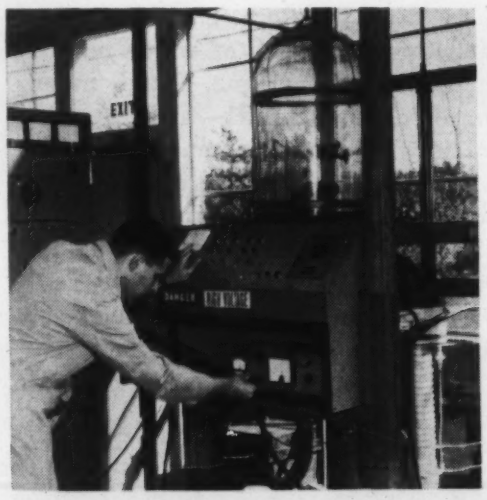
For more information, turn to Reader Service Card, circle No. 376

News OF INDUSTRY

Lab Specializes in Beryllium, Other New Metals



New properties. *These autoclaves test resistance to the hot, high pressure water encountered in nuclear energy systems.*



New methods. *Metals can be welded in a vacuum with electron gun (left). Zirconium is ground in a ventilated hood (right).*

New forms. *Deficiencies of a material can often be overcome by coextruding it with another (see article, p 91).*

■ A $2 million laboratory devoted entirely to research and development on metals and ceramics was dedicated recently by Nuclear Metals, Inc. in Concord, Mass.

In its 16 years of existence, Nuclear Metals has worked on virtually every existing metal. Currently, the most important projects include: 1) beryllium, of interest to aircraft and rocket designers because of its light weight, 2) fuel elements for nuclear reactors of advanced design, and 3) high melting metals, such as tungsten, molybdenum, tantalum, rhenium and rhodium. (See p 138.)

The nature of many of the materials handled at the laboratory has made necessary elaborate safety precautions. In fact, almost one-third the cost of the building is accounted for by safety equipment. A major item is the 32 separate ventilation systems capable of exhausting nearly 150,000 cfm of completely filtered air. Other features: a giant vacuum cleaning system, easy-to-clean plastics floors, glass drains, closed-circuit television, a medical clinic, and a completely equipped fire brigade. The plant also has eight monitoring stations on the grounds to sample air, soil, ground water, rain and snow for evidence of contamination.

Most of Nuclear Metals' work has been on the so-called "exotic" materials required in nuclear energy equipment or advanced aircraft. The company was formed in 1942 as the Metallurgical Project of Massachusetts Institute of Technology. Its first assignment was to develop uranium melting techniques for the Stagg Field reactor at the University of Chicago. In 1954, the Project was taken over by Arthur D. Little, Inc., and Allegheny Ludlum Steel Corp.

(more News on p 178)

makes Fluoroflex®-T pipe permanently corrosion-proof

USING the pipe lining *material* that handles highly corrosive fluids is only half the job. Keeping it *in place*, despite wide temperature fluctuations, is equally important. Fluoroflex-T Type S piping solves both problems . . . assuring unequalled pipe and fitting life.

Lining is universally inert to all corrosives. It's made of Fluoroflex-T, a high density, non-porous compound* of virgin Teflon.

Liner and housing in thermal equilibrium, through an exclusive process developed by Resistoflex. It compensates for thermal expansion differential between the Teflon and housing, eliminating fatigue collapse, and cracking at the flare.

Bulletin TS-1A gives more details. Write Dept. 168, RESISTOFLEX CORPORATION, Roseland, N. J. Other plants: Burbank, Calif.; Dallas, Tex.

* *Pat. No. 2,752,637*

®Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
®Teflon is DuPont's trademark for TFE Fluorocarbon resins.

RESISTOFLEX

For more information, turn to Reader Service card, circle No. 461

News OF INDUSTRY

Reactor Will Test Materials, Fuels

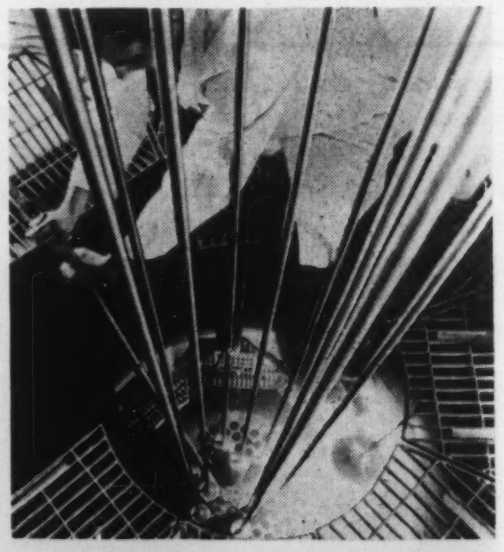
Complete testing and evaluation of power reactor materials and fuels will be more readily accomplished when the first atomic testing reactor to be operated by private industry is completed by Westinghouse Electric Corp. sometime next May.

According to Westinghouse, the testing reactor is being built to "serve as an additional research and testing tool to help solve the many fuel and materials problems which must be solved if economic nuclear power is to become a reality." To date, there are only three testing reactors in this country and they are all owned by the Atomic Energy Commission.

Stability is basic problem

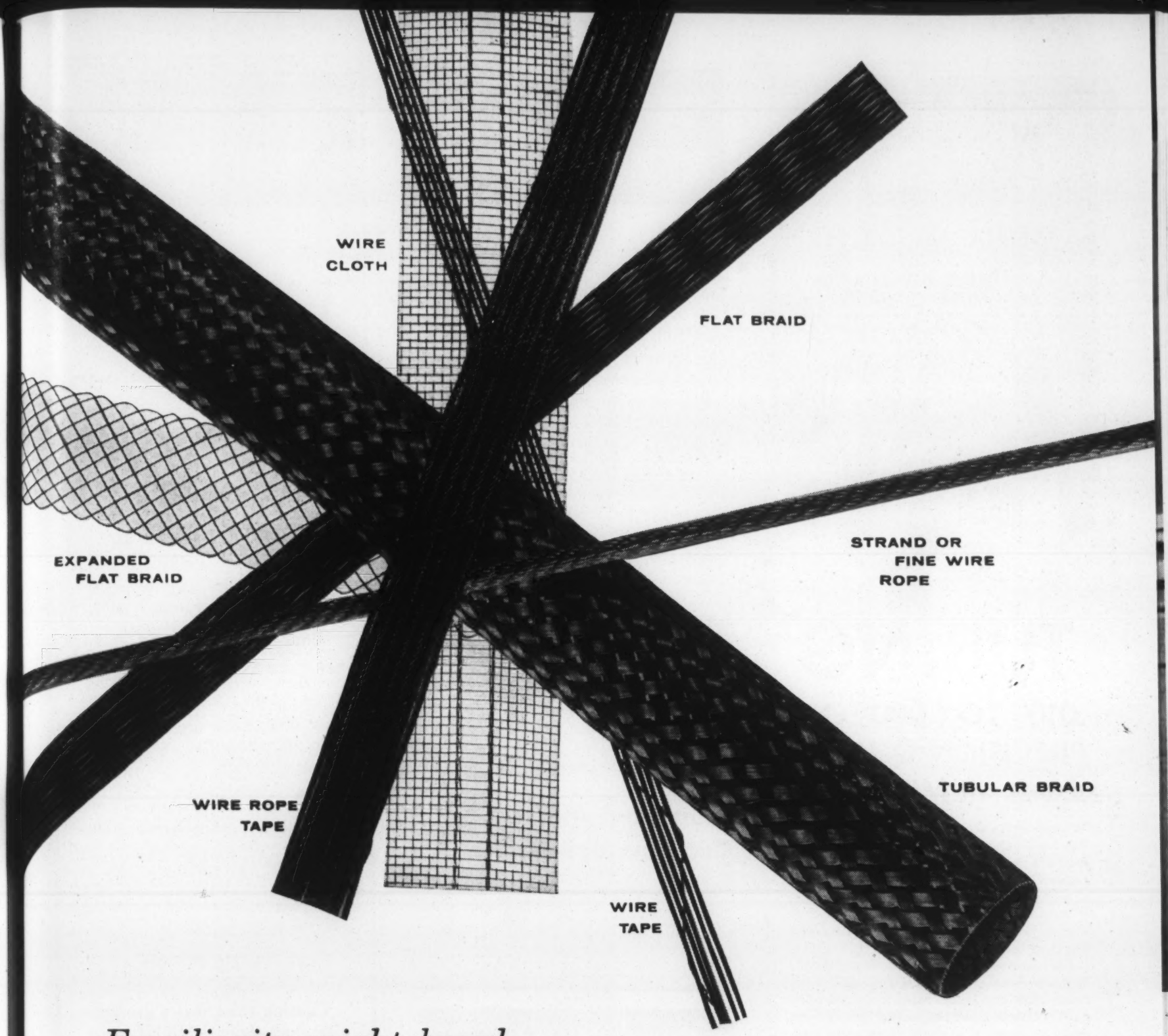
When complete, the testing reactor will be used to determine the behavior and performance limits of individual materials and combinations of materials under a wide variety of pressure, temperature and neutron environments. Some of the materials to be tested include: uranium 235, uranium 233, plutonium and thorium—each of which may be in the form of a gas, liquid, metal, ceramic, or cermet—and a wide variety of cladding materials. The basic problem encountered with these materials is that of stability in relation to allowable burnup and the temperature at which that burnup occurs. Other problems include embrittlement, cracking, corrosion, etc.

In addition to the reactor itself,



***Control rod extensions** are placed in position.*

For more information, circle No. 400 ➤



Familiarity might breed

NEW PRODUCT IDEAS!

The wire fabrications shown here, highly developed specialties of National-Standard, are available in many types and sizes. Each can be produced in any metal that can be drawn into wire.

These materials are used in numerous products today for many different reasons . . . for strengthening, stiffening, protection, safety, decoration, filtering, screening, heat or electrical conductivity, grounding, etc., etc.

Can one of these materials meet a present or new product requirement of yours? You'll never find an organization more cooperative or better qualified to help you fully explore any such ideas. Just get in touch with National-Standard, Niles, Michigan.

NATIONAL NS NATIONAL-STANDARD NILES, MICHIGAN **STANDARD**

NATIONAL-STANDARD, Niles, Mich.; *fine wire, stainless, music spring and plated wires, flat and tubular braid and wire cord*
WORCESTER WIRE WORKS, Worcester, Mass.; *music spring, stainless and plated wires, high and low carbon specialties* • **REYNOLDS WIRE, Dixon, Ill.;** *industrial wire cloth*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • **ATHENIA STEEL, Clifton, N. J.;** *flat, high carbon spring steels*
CROSS PERFORATED METALS, Carbondale, Pa.; *industrial, commercial, and decorative perforated metals*

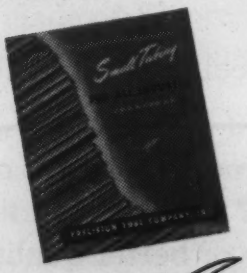
TUBING

.010" TO 1.000" O.D. PRECISION QUALITY REGULAR MILL PRICES

Whatever the size, shape or alloy there's a Precision Tube to meet your requirements . . . made to precision specifications yet costs only regular mill prices. Round, rectangular, oval or square, preformed to special shapes . . . in copper, brass, aluminum, nickel, and nickel-alloys, Ni-Span "C", phosphor-bronze and nickel silver.

For improved quality at lower costs specify Precision Tubing. It is the tubing consistently unequalled and unsurpassed in comparative quality tests of accuracy, temper, straightness and roundness. It is yours at no extra cost.

Whatever your product plans you can rely on Precision for finish, accuracy and quick deliveries. For information on small tubing and specifications to use in selecting tubing write for the new data book to Department #6, Precision Tube Company, North Wales, Pa.



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PRECISION TUBE COMPANY

For more information, circle No. 373

News OF INDUSTRY

the installation will include facilities for pre-irradiation and post-irradiation testing of nuclear fuels and materials. A hot laboratory containing three high level hot cells will permit examination and metallurgical evaluation of materials irradiated in the reactor.

Available to colleges

According to Westinghouse, a portion of the testing reactor will be set aside to be available free of charge to any research or study program that is "supported and wholly financed by a college or university." Westinghouse also hopes to offer cooperative summer programs in nuclear study and research to instructors and professors of physics and nuclear sciences. Eventually, the reactor is expected to provide limited quantities of radioisotopes for industrial and medical use.

Aluminum Alloys Get New Designations

A new series of temper designations has been assigned by the Aluminum Assn. to a group of stress

Materials show—Shown here is a part of the recent Design Materials Show, including a glimpse of M/DE's own display. The show, sponsored by the Industrial Designers Institute and held Oct 8-10 in New York, was devoted exclusively to those industrial designers, engineers, product planners, research directors, etc., who are responsible for the selection of materials in product design and development. Materials exhibited at the show included: metals, plastics, glass, wood, composition materials and textiles. The show is planned as an annual event for October.

Hand tools are safer and better looking with Reynosol-coated handles.

REYNOSOL* HOT DIP COATINGS

You name it—*any* metal object—and Reynosol can coat it!

Both decorative and functional, Reynosol vinyl chloride coatings solve thousands of finishing problems. Your products will boast smooth, high gloss finishes that are:

- CHEMICALLY INERT
- SCUFF RESISTANT
- COLORED TO SPEC.
- INSULATING
- RESILIENT
- TIGHTLY BONDED

Coating thicknesses are precise, range from 10 to 150 mils.

Reynosol hot dip coatings are already hard at work on tool handles, battery racks, marine hardware, high voltage coils, and a host of other products. And Reynolds is ready right now to work out your specifications. *Write or phone today for full information.*

Member Vinyl Dispersion Division, SPI

*REG. TRADEMARK

Reynolds Can Coat It—If Anyone Can!

REYNOLDS CHEMICAL PRODUCTS COMPANY

Whitmore Lake, Michigan • Phone: HIckory 9-9361

DIVISION OF STUBNITZ GREENE CORP.

For more information, circle No. 388

Type 304 stainless plate, dimensions: 6⅝" thick x 75" diameter. Weight, 8655 lbs.

take a look

...at the clean edges of this stainless plate accurately cut by Carlson

THIS stainless plate illustrates something that's almost a Carlson exclusive. Few producers can make plates of such heavy gauge, and fewer still have the long experience in flame cutting stainless to precise dimensions. To develop the proper equipment, the exact gas and iron powder formula, and the special nozzles, took Carlson engineers years of effort. But the result was worth it.

The edges achieved by these improvements reduce the cost of subsequent machining operations. And every Carlson stainless plate—whether heavy or light gauge—carries its own identification. Its chemical and physical properties are known and recorded. Its dependable performance on the job is assured.

The complete reliability of every Carlson service will materially reduce your ultimate costs. Our specialists make certain that your instructions are followed in every detail. Write, wire or phone for further information on all our services in stainless steel.

G.O.CARLSON Inc.

Stainless Steels Exclusively

126 Marshalton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS AND SHEETS (No. 1 Finish)

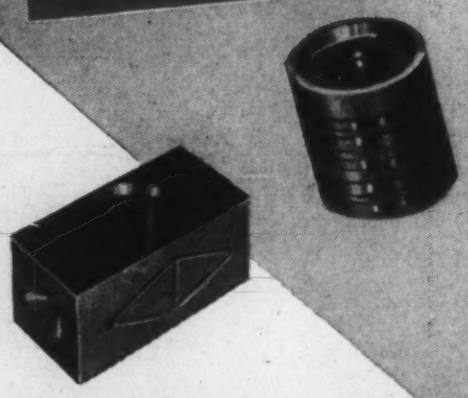
For more information, turn to Reader Service card, circle No. 363

FASTEST SERVICE...

promet
Engineered Bronze

BEARINGS-BUSHINGS
WEARING PARTS

Sound castings of any size, shape or section, rough cast or machined to precisely controlled tolerances. Difficult oil grooving... smooth even around acute bends.

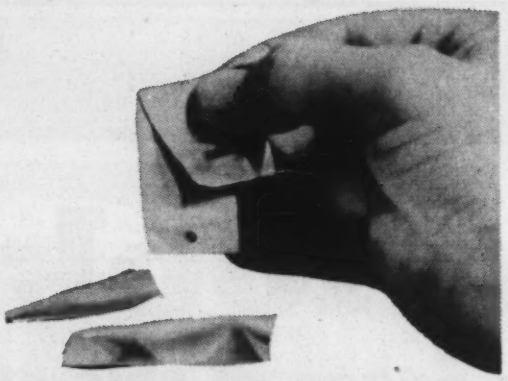


Write for literature and service data sheets, or send prints and condition of operation for recommendations and quotations.

Promet Fully Machined
CORED & SOLID BRONZE BAR STOCK
Saves Time, Tools & Money!

THE American Crucible PRODUCTS CO.
1325 Oberlin Avenue — Lorain, Ohio, U. S. A.

ONE-STEP PLATINUM PLATING PROCESS!



Sel-Rex®

PLATANEX

eliminates intermediate scratch brushing or burnishing

Produces consistent quality, essentially nonporous Platinum plate for high temperature and other exacting industrial applications. The photograph demonstrates the low stress and ductility of the new Platinum plating process — these electroformed strips are twisted and crimped *without cracking*. PLATANEX is also available in I-BD formulations which produce brilliant deposits for decorative applications. Ask for Bulletin PLT-1 for full details.

PRECIOUS METALS DIVISION

SEL-REX CORPORATION

NUTLEY 10, NEW JERSEY

Manufacturers of Exclusive Precious Metals Processes, Metallic Power Rectifiers Airborne Power Equipment, Liquid Clarification Filters, Metal Finishing Equipment and Supplies.

For more information, turn to Reader Service card, circle No. 433

News OF INDUSTRY

relieved aluminum alloy mill products.

According to the Association, the new designations are necessary because most of the larger wrought aluminum products produced today are stress relieved to minimize warpage during machining.

The new temper designations, which apply only to heat treatable aluminum alloys, are composed of three digits following the letter –T. The first digit indicates the basic temper. The second digit, arbitrarily assigned as "5" in all cases, is the key digit and denotes that the material has received a stress relief treatment. The last digit indicates the method of stress relief: digit 1 indicates stretching, digit 2 indicates compressing, and digits 3-9 have been reserved for other methods which might be developed.

Some examples of alloys and products employing the new tempers are: Solution heat treated 2024 aluminum plate stress relieved by stretching is now designated 2024-T351. After artificial aging, this alloy is designated 2024-T851. Similarly, solution heat treated 2014 and 6061 aluminum alloy plate stress relieved by stretching are now designated –T451. When artificially aged, these alloys are designated –T651.

Engineers

James M. Evans has been appointed field engineering manager, General Transistor Corp.

John Aldred is now chief engineer, Sherman Products, Inc.

James W. Macri and **Robert Katz** have been named senior engineers, Engineering and Construction Div., American Cyanamid Co.

E. N. Smith has been appointed technical director, Chemical and Metallurgical Laboratory, Kennametal Inc.

John H. King, Archer-Daniels-Midland Co., Ltd., has been chosen a national director of the American Foundrymen's Society.

Walter R. Woodward has been named director of engineering, Dynametrics Corp.

Dr. R. J. Reynolds has been appointed research supervisor, and Dr. N. R. Legge assistant department

Pioneers In element 49

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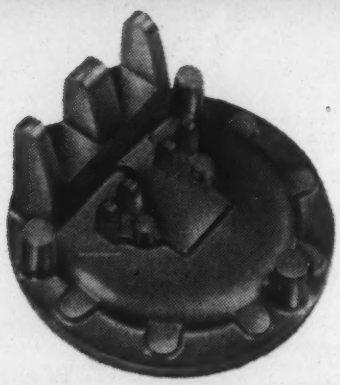

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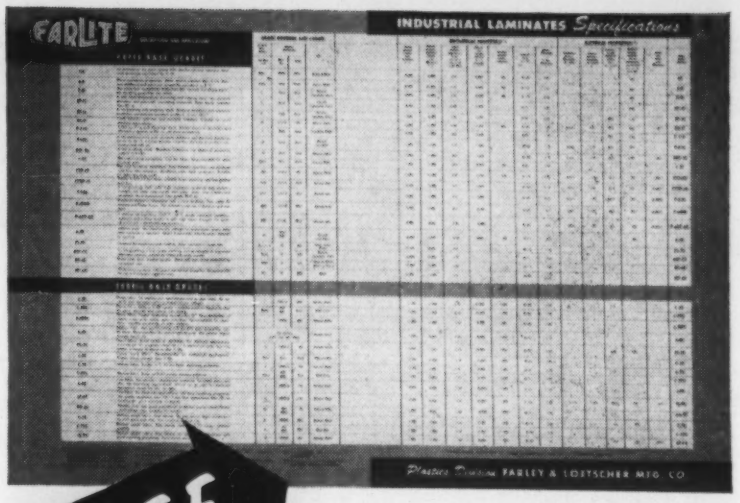

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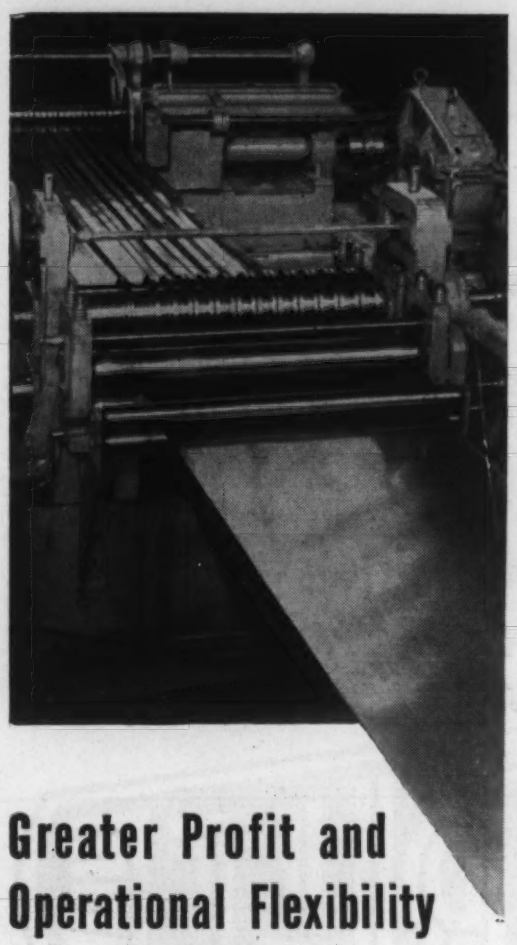

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News OF INDUSTRY

head, Polymer and Chemical Applications Dept., Shell Development Co.

Dr. Walter Welkowitz has been appointed director of engineering, Vibro-Ceramics Div., Gulton Industries, Inc.

Frederick R. Gruner has been named director of engineering, and **Howard M. Gammon** chief engineer, Purolator Products, Inc.

Robert C. Spencer, Jr., has been appointed turbine advance design engineer, Steam Turbine-Generator Dept., General Electric Co.

Walter P. Stroud has been appointed plant engineer, Film Div., American Viscose Corp.

Companies

National Aluminate Corp. has acquired **Oil Products and Chemical Co., Inc.,** and will operate it as a division.

Colorado School of Mines has opened its new million dollar metallurgical engineering building.

Beckman Instruments, Inc., has formed a new subsidiary, **Shockley Transistor Corp.**

Pittsburgh Plate Glass Co. will construct a multi-million dollar glass fabricating plant in Crestline, Ohio.

Philco Corp.'s Government and Industrial Div. has formed a new advanced weapon systems group.

Chromalloy Corp. has acquired **Propellex Chemical Corp.,** which will be operated as **Propellex Chemical Div.**

National Forge Co. is the new name for **National Forge and Ordnance Co.,** Irvine, Pa.

Glidden Co.'s Organic Chemical Div. will construct a $2 million plant for the production of synthetic laevomenthol in Jacksonville, Fla.

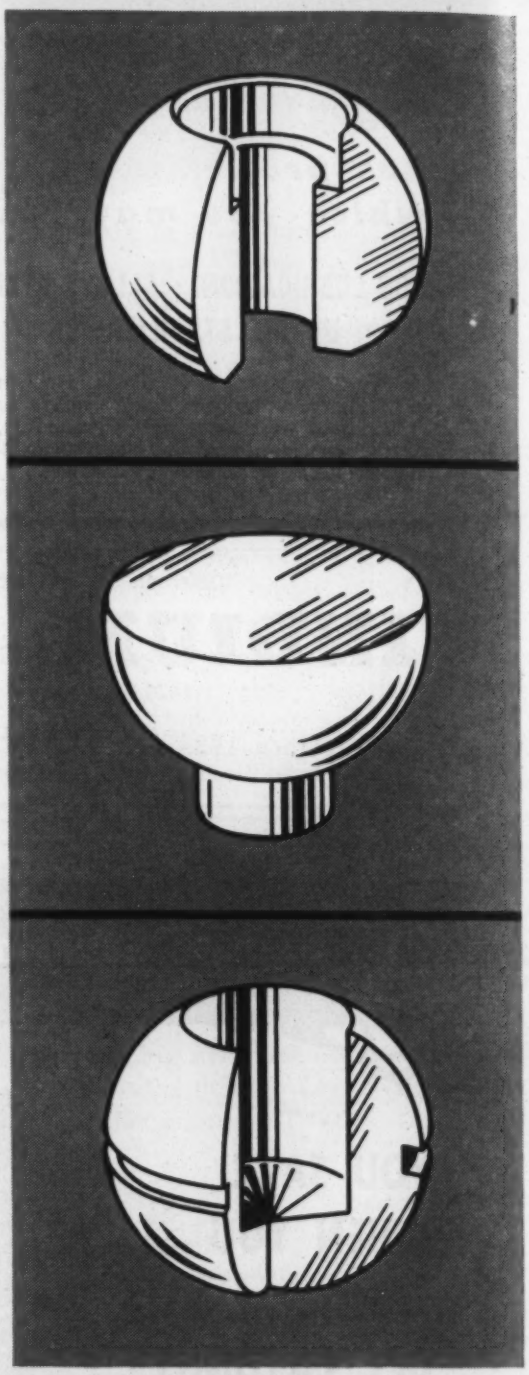
Standard Steel Corp. has begun manufacturing and engineering operations in its new facilities in Los Angeles. The new unit will be known as the **Cryogenics Div.**

Alpine Electronic Components Corp. is a newly formed company located at Wolcott Rd., Waterbury, Conn.

Bendix Aviation Corp.'s Industrial Controls Section is building new facilities to be located at 21820 Wyoming Ave., Detroit 37.

U. S. Steel Corp. has begun construction of a new blooming and struc-

MODIFIED BALLS



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- Wide range of textures and colors to suit your needs.

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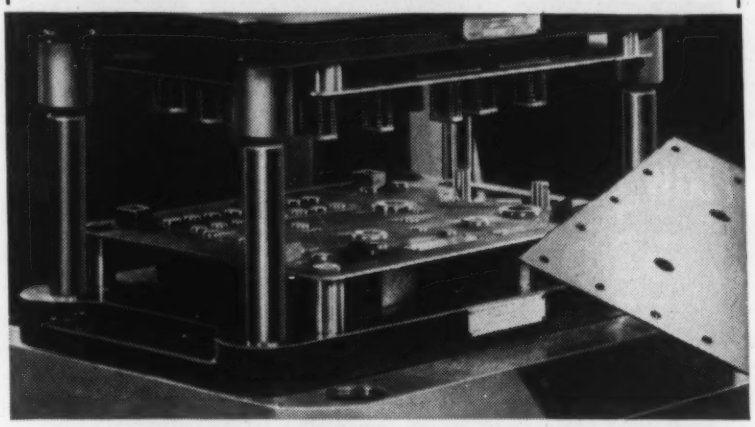

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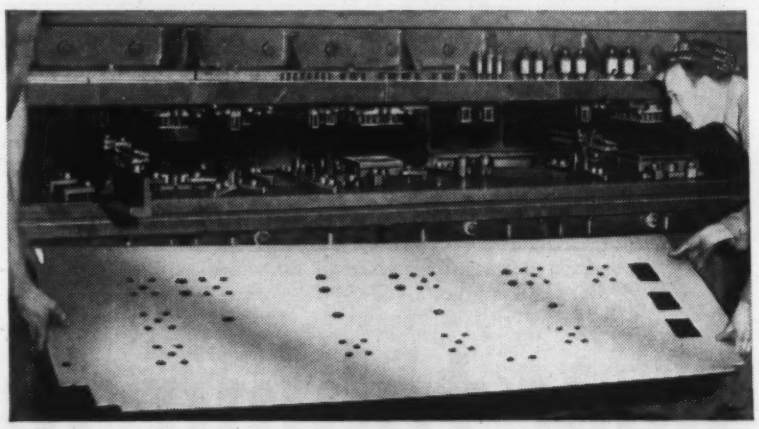

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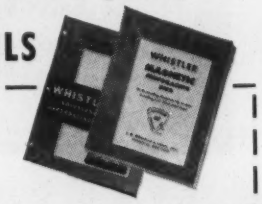

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News OF INDUSTRY

tural mill at its Chicago South Works.

Spectra-Strip, Wire and Cable Corp. is the new name for **Organic Development Corp.,** Garden Grove, Calif.

General Electric Co.'s Electric Lamp Div. has formed a new Lamp Metals and Components Dept.

Industrial Instruments, Inc., has purchased **Mosher Electronic Controls,** Larchmont, N. Y.

Linde Co., a div. of Union Carbide Corp., has broken ground for a multi-million dollar liquid oxygen and nitrogen plant at Pittsburgh, Calif.

Holyoke Plastics Co., Inc., formerly **Holyoke Plastics Corp.,** is now operating under a new corporate charter and is no longer a subsidiary of **Noma Lites, Inc.**

Lindberg Industrial Corp. has acquired **Continental Industrial Engineers,** Chicago, Ill.

Societies

American Society for Metals announces the following recipients of its 1958 annual awards: Dr. Albert J. Phillips, American Smelting and Refining Co.—Gold Medal; Crawford H. Greenewalt, E. I. du Pont de Nemours & Co., Inc.—Medal for Advancement of Research; and William G. Pfann, Bell Telephone Laboratories, Inc.—Albert Sauveur Achievement Award. Ernest E. Thum, editor-in-chief of ASM's *Metal Progress,* was awarded Honorary Membership.

American Welding Society announces the following officers: president—Gustav O. Hoglund, Aluminum Co. of America; first vice president—Charles I. MacGuffie, General Electric Co.; vice president—R. David Thomas, Jr., Arcos Corp. Directors are: Edward C. Miller, Oak Ridge National Laboratory; Arthur A. Holzbaur, Sun Shipbuilding & Dry Dock Co.; Frank G. Singleton, Singleton Welding Supply Co.; Francis V. McGinley, Victor Equip-

AWARDS COMPETITION — Are you working on your entry for M/DE's third annual Awards Competition? See pp 115-118 for full details.

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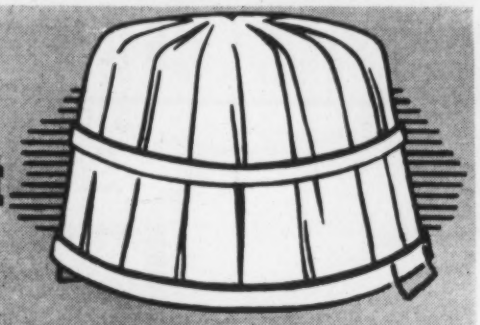

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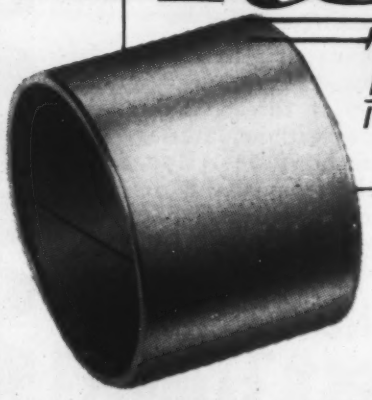

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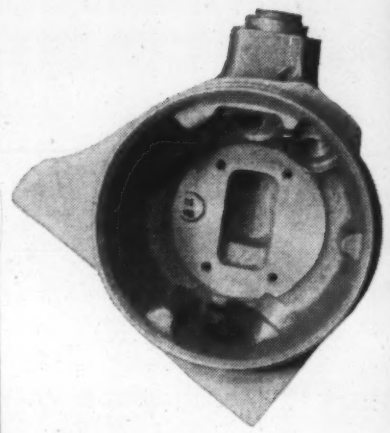

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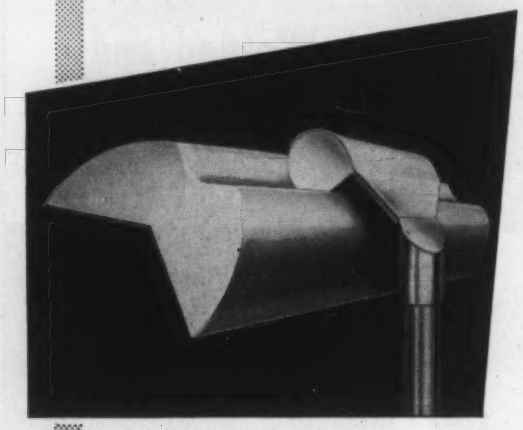

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News OF INDUSTRY

ment Co.; James N. Alcock, Saginaw Welding Supply Co.; and Donald B. Howard, ACF Industries, Inc.

Foundry Educational Foundation has elected the following officers: president—F. X. Bujold, Ford Motor Co.; vice president—F. G. Steineback, Penton Publishing Co.; secretary—W. B. Bishop, Archer-Daniels-Midland Co.; and treasurer — E. M. Knapp, Ferro Machine & Foundry, Inc.

Meetings

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, electric furnace steel conference. Detroit. Dec 3-5.

RUBBER & PLASTIC ADHESIVE & SEALANT MFRS. COUNCIL. Washington, D. C. Dec 8-9.

AMERICAN NUCLEAR SOCIETY, 1st annual meeting. Detroit. Dec 8-10.

5TH NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL, American Society for Quality Control, Institute of Radio Engineers, American Institute of Electrical Engineers, and Electronic Industries Assn. Philadelphia. Jan 12-14.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York City. Jan 19-24.

SOCIETY OF PLASTICS ENGINEERS, INC., 15th SPE annual technical conference. New York City. Jan 27-30.

AMERICAN SOCIETY FOR TESTING MATERIALS, Committee Week. Pittsburgh. Feb 2-6.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 14th SPI reinforced plastics division conference. Chicago. Feb 3-5.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, annual meeting. San Francisco. Feb 15-19.

STEEL FOUNDERS' SOCIETY OF AMERICA, 57th annual meeting. Chicago. Mar 16-17.

AMERICAN WELDING SOCIETY, 40th annual convention and welding exposition. Chicago. Apr 6-10.

METAL POWDER INDUSTRIES ASSN., annual meeting. Detroit. Apr 20-22.

4TH ANNUAL DESIGN ENGINEERING CONFERENCE, American Society of Mechanical Engineers. Philadelphia. May 25-28.

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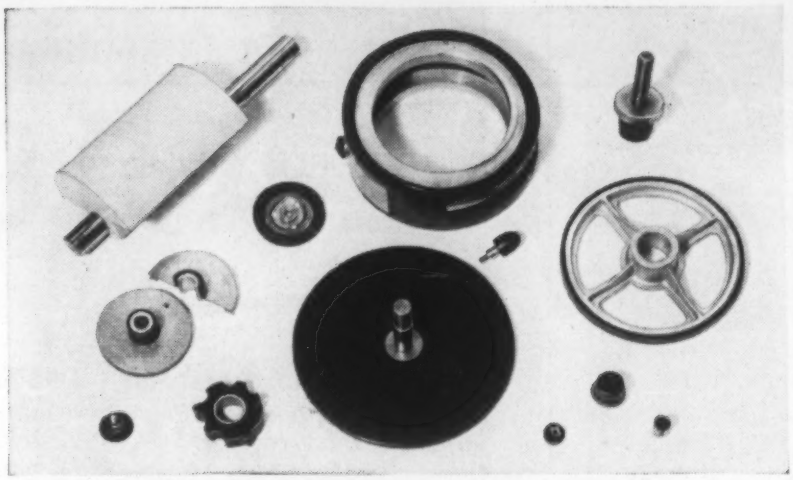

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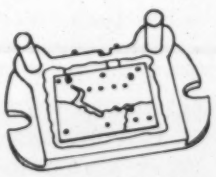
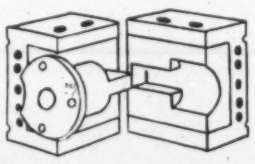


Repairing broken dies

Anchoring punches & dies



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*Product Development by William M. Schmidt Associates.

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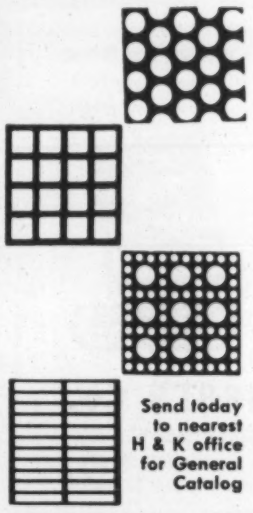

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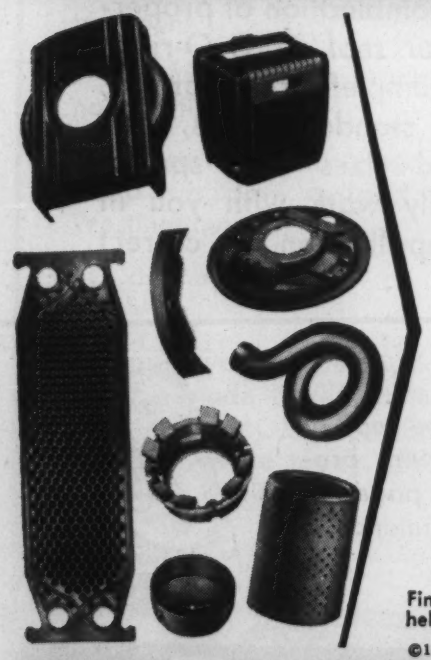

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Books

Progress in Plastics: 1957. *Edited by Phillip Morgan. Philosophical Library, Inc., New York, 1958. Cloth, 6 by 10 in., 394 pp. Price $22.50*

The nineteen papers given in this book, written by authorities from England, the United States and Germany, contain information on some of the most recent international advances in plastics technology, particularly in the fields of polyethylenes, vinyls, polystyrenes, reinforced plastics and fluorine polymers. Some of the papers deal with current developments in the theory and practice of plastics extrusion and injection molding. The papers were read at the 1957 British Plastics Convention held in conjunction with the British Plastics Exhibition.

ASTM Standards on Paper and Paper Products and Shipping Containers. *American Society for Testing Materials, Philadelphia. 1957. Paper, 6 by 9 in., 420 pp. Price $4*

The various ASTM standard and tentative specifications, test methods and definitions of terms pertaining to paper, paper products and shipping containers are grouped together in this publication. It contains 102 standards and related information.

ASTM Standards on Rubber Products. *American Society for Testing Materials, Philadelphia. 1958. Paper, 6 by 9 in., 908 pp. Price $8.50*

Included are 145 standards on rubber products of which 61 are new, revised or have undergone a recent change in status. Sixteen of the standards were not included in the 1957 edition.

Among the general subjects covered are: processibility, chemical, aging, weathering and low temperature tests; automotive and aeronautical rubber; packing and gasket materials; rubber-coated fabrics; hard rubber; rubber adhesives; synthetic elastomers; and non-rigid plastics.

The Encyclopedia of Chemistry: Supplement. *Edited by G. L. Clark, G. G. Hawley and W. A. Hamor. Reinhold Publishing Corp., New York. 1958. Cloth, 7 by 10 in., 338 pp. Price $10*

The *Supplement* adds over 200 articles of primary and current importance to the *Encyclopedia of*

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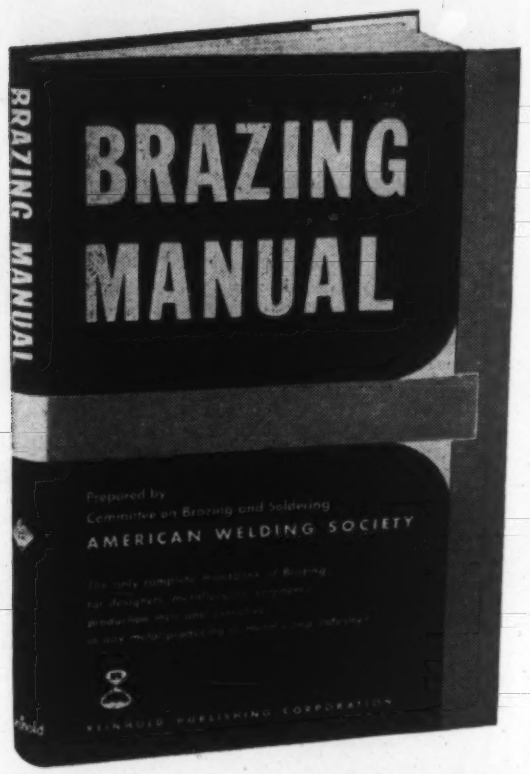

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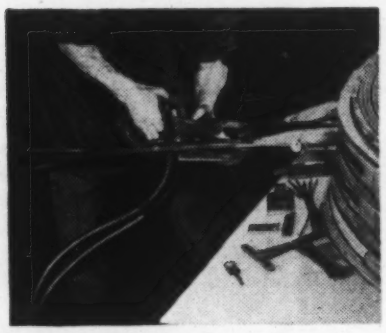

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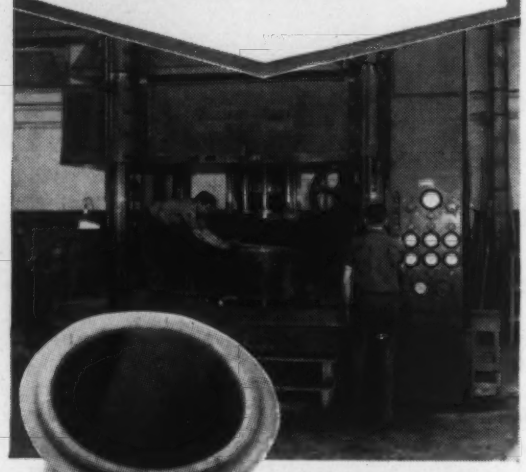

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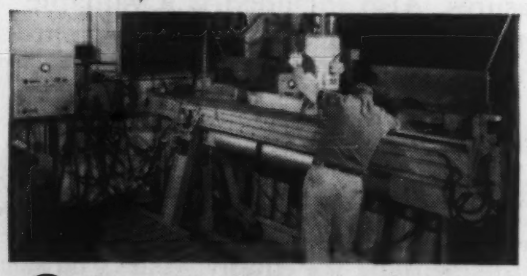

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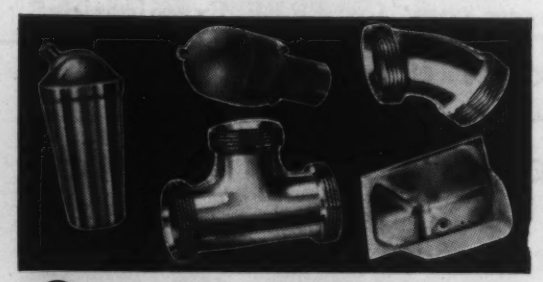

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TECHNICAL LITERATURE

Chemistry. The arrangement of the book is identical to that of the parent book: articles appear alphabetically by subject. Included in the book are articles on such subjects as phosphorescence, polyurethanes, halocarbon compounds, cermets, nuclear reactor materials and ceramics.

Reports

Bronze casting standards RADIOGRAPHIC STANDARDS FOR BRONZE CASTINGS. *Bureau of Ships, U. S. Navy. 1958. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $25 (PB 131854)*

A set of standard x-ray radiographic film copies for use in the evaluation of discontinuities in tin-bronze castings. Five types of discontinuities are illustrated: gas porosity, shrinkage, sand inclusions, chaplets and tears.

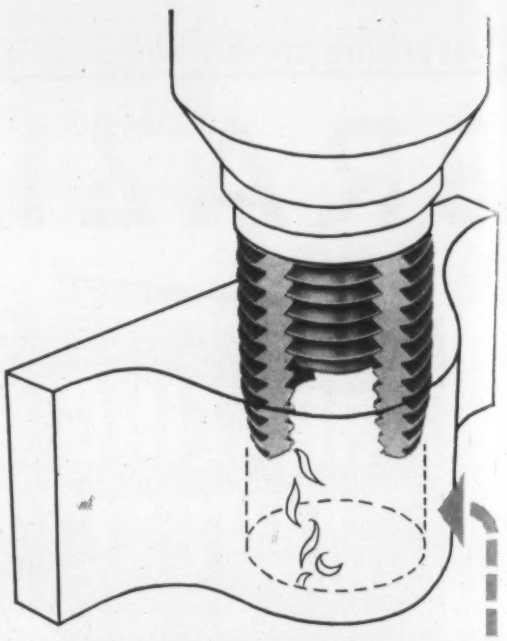
Cobalt COBALT AND ITS ALLOYS. *F. R. Morral, Cobalt Information Center. 1958. 125 pp. Available from Cobalt Information Center, c/o Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.*

Presents a summary of allotropy and phase diagrams. The section on allotropy contains more than 90 references to literature from 1911 to 1958. Two-color phase diagrams for the cobalt binary alloys are included as well as more than 900 references to binary, ternary and quaternary systems.

Corrosion of magnesium A BASIC STUDY OF CORROSION OF MAGNESIUM. *R. R. Addiss and others, Cornell University for Wright Air Development Center. Dec '57. 57 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.50 (PB 131-662)*

Study of the formation and structure of surface films appearing on magnesium during corrosion. Studies were also made of oxidation of magnesium surfaces covered with the "first film."

PROPERTIES of most engineering materials can be found in the second edition of M/DE's *Materials Selector* reference issue, published in October. Names and addresses of suppliers are also listed.



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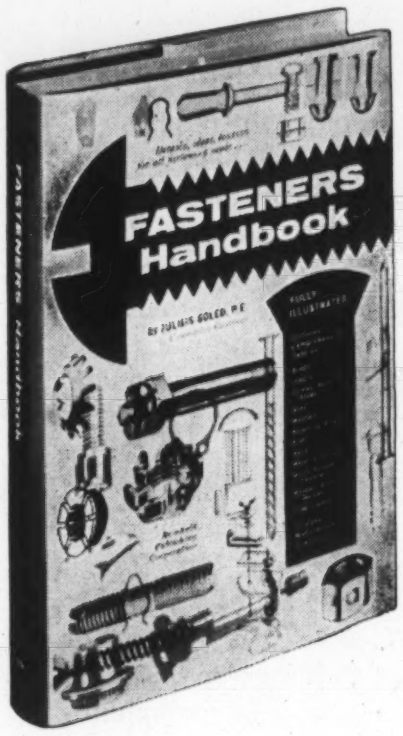

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This is the *only* fastener reference which relates the actual uses of fasteners in one industry to those of another. The result is concrete examples of money-saving applications for all designers and manufacturers. The book also points out the plus values of many less known but equally valuable fasteners.

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Fastener development has far exceeded the published information on fasteners. This handbook meets the tremendous need for a reliable, current, and authoritative reference to fasteners and fastener resources.

Due to its complete coverage, Fasteners Handbook can be profitably used by design engineers, mechanical engineers, patent attorneys, sales personnel, fastener distributors and jobbers—in fact, anyone who needs solid information on fasteners available for mechanical assembly.

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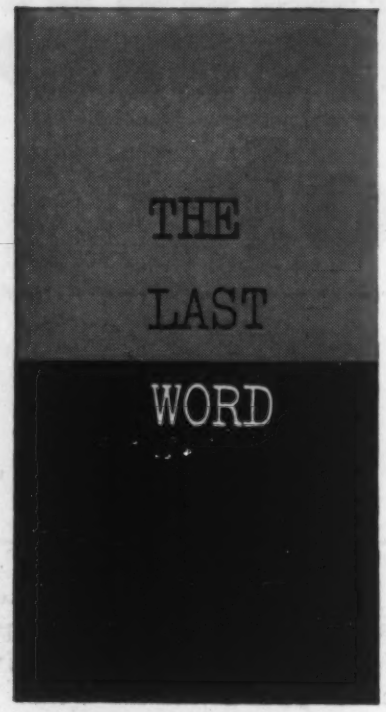

by ***H. R. Clauser***
Editor

Eat It and Like It

I ate some space food recently. The applesauce and the bacon and eggs, which I squeezed into my mouth from a specially designed "toothpaste" tube, were suprisingly tasty. The occasion was a talk and demonstration given by Colonel J. P. Taylor of Wright Air Development Command on problems that must be solved before man can travel for long periods of time through zero G space.

Not the least of the many troublesome problems is how to handle body wastes on a long intra-solar trip. It wouldn't do to simply eject the waste from your space ship, because it would annoyingly accompany you through space. One promising suggested approach to the waste problem is to have the space traveller eat it. This could be arranged for by separating out the pure water by electro-osmosis and feeding the solid materials to algae which would be carried along for this purpose. Thus, the algae would provide a limited source of fresh food replete with essential vitamins and proteins. And we hope, it would be tasty too.

How Foggy Are You?

Have you ever checked to see how readable your technical reports are? How much of a chore is it for your boss or your co-workers to read your reports and understand what you are saying? It is quite simple to find out by using one of the several readability yardsticks that have been developed in recent years.

Perhaps the easiest one to use is the so-called Fog Index. It was developed by Robert Gunning and is explained in detail in his excellent book, "The Technique of Clear Writing." Here is how you can find the Fog Index of a passage of your writing: 1) Figure the average sentence length by dividing the total number of words by the number of sentences. 2) Count the number of words having three or more syllables per 100 words. 3) Add these two numbers and multiply by 0.4. The answer is your Fog Index.

The Fog Index numbers correspond rather closely to school-grade levels of reading difficulty. Thus, writing that has a Fog Index of 17 requires the reading skill of a college graduate. This does not mean that if your boss is a college graduate, your reports may have a Fog Index of 17. Experience and tests over a number of years tell us that if your Fog Index is over 12, the reader is likely to find your copy tough going. There is a good chance that he will either not understand what you are trying to say or that he will get tired and just stop reading. In either case you will have failed to communicate. So, before handing in that next report, run a Fog Index on it. If it is above 12, chances are it could stand some sentence pruning and fewer polysyllables.

Heads of All Shapes

Everyone knows that girls prefer the football hero with his big varsity letter to the bespectacled studious honor student. Now the Asbury Park High School in New Jersey has decided to do something about this. They are going to award varsity letters not only to athletes but also to honor students. And this academic "A" will be just as big as the letters given for athletic achievement. At first glance, this move appears to be quite reasonable and fair. But it seems to me dangers and complications may arise. First, the eggheads might get swelled heads. Second, the shrunken heads ("C" students) might get inferiority complexes. And third, the disgruntled football heroes might get sore heads over having to share their prestige with the eggheads.

Metals and Nonmetallics Mix

A few months ago in this column I suggested that more technical metal societies officially recognize the existence of nonmetallic materials as the American Welding Society has done. I was quickly informed by Ted DuMond of the American Society for Metals staff that ASM is definitely aware of nonmetallics. As proof of their interest they had a technical session at their annual meeting in October titled "The Metallurgist Looks at Nonmetallic Materials." This, ASM says, is only the first step towards greater coverage of the nonmetallics field in the future.

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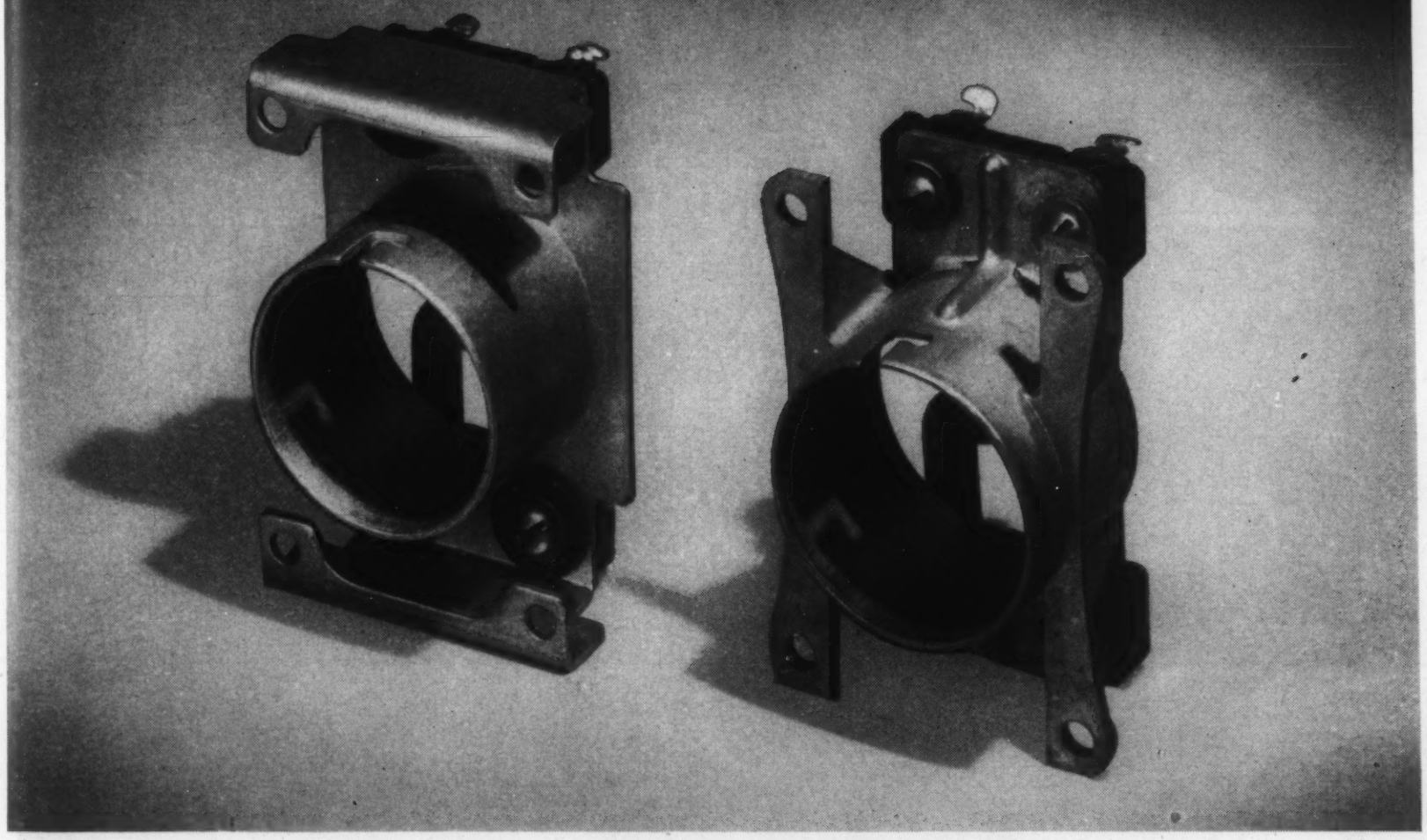

Redesigning this vacuum tube base cut manufacturing costs by 50%.

The old base (shown at left) required seven operations from blanking the steel frame to staking the socket in position.

As a zinc die casting (shown at right), only one operation — punching the tube pin slot — was necessary. By die casting this part from zinc rather than from aluminum, the following *additional* advantages were achieved:

. . . Less draft on the socket
. . . Greater overall strength
. . . Lower die cost

For similar savings review your metal parts that possibly can be produced as ZAMAK alloy die castings.

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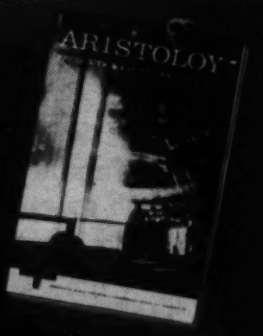

NEW PRODUCTS & FACILITIES CATALOG

Describes melting, rolling, thermal treating and finishing capacity of Copperweld's Aristoloy Steel Division. Complete product listing for Aristoloy carbon, alloy, stainless, leaded and nitriding steels. Send for your copy today.

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COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4021 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

For more information, turn to Reader Service Card, circle No. 462

CUTS 'EM DOWN, right or left. This powerful motor grader, shown here doing "high bank-cutting," can work its big blade in many seemingly awkward positions. It depends on a drive axle of alloy steel containing Nickel to withstand rugged operating conditions. Photo courtesy of Le-Tourneau-Westinghouse Company, Peoria, Illinois.

How nickel-containing alloy steel keeps a workhorse shouldering its load

Step on this motor grader's accelerator . . . feel its 15 tons spring to life . . . as it rips out stumps and roots . . . scrapes out rocks and boulders.

What gives it the "drive" to push relentlessly along day after day?

Its super-strong nickel-alloyed steel drive axle.

This two-part drive axle is described by the manufacturer as one of the most critical parts of the road grader. Only 3½ inches in diameter, it has to be strong to push tons of hard-packed earth and rock. And it has to be shock resistant to withstand hours of abuse on the job.

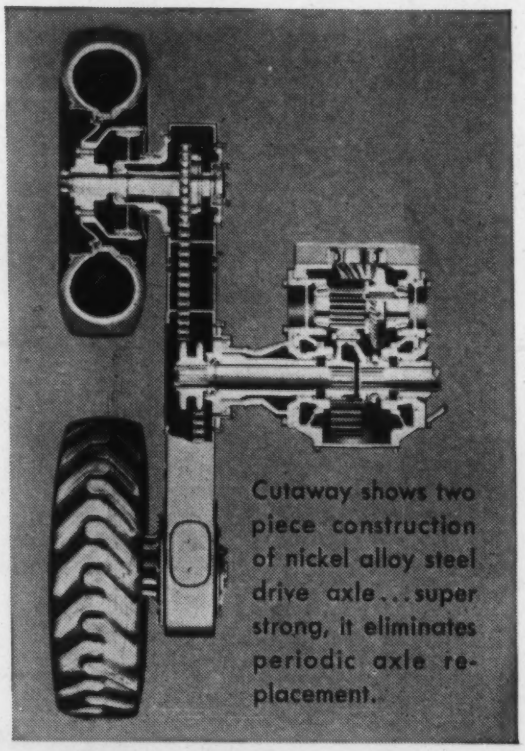
What's more, the superior properties of this shaft must be uniform from surface to center and from one end to the other.

Fortunately, Le-Tourneau-Westinghouse engineers had years of experience with shafts and axles on other similar equipment. They knew they could count on a nickel-containing alloy steel, AISI 4340 H, to take this punishment. Millions of hours on the job proved them correct.

Because 4340 steel is widely recognized as the general purpose alloy constructional steel for through hardening heat treatment, it is readily available from steel service centers throughout the country.

Are you looking for a metal with dependable strength . . . added toughness or corrosion resistance . . . excellent resistance to fatigue, shock, stress or wear? A nickel-alloyed steel may be just what's needed to help a product of yours "make the grade" with users. Talk it over with us. We can make available to you technical data based on years of specialized experience with alloys containing nickel.

The International Nickel Company, Inc.
67 Wall Street INCO New York 5, N. Y.



Cutaway shows two piece construction of nickel alloy steel drive axle . . . super strong, it eliminates periodic axle replacement.

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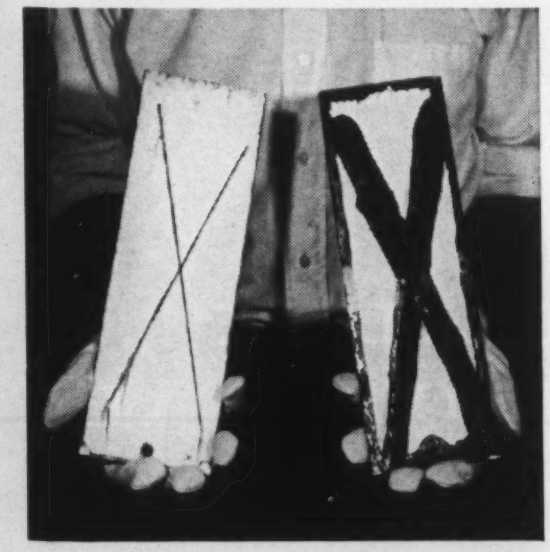
Read the Temperature and SAVE!

New Cold Bonderite System Cuts Heat Costs Up to 70%

The temperature gauges on the input lines of a typical Cold Bonderite System installation tell the story. 40° to 75° cooler in cleaner, rinse and Bonderite than in the conventional hot phosphating installation.

And all that heat saved translates into dollars saved, because chemical costs are comparable, as is the effective protection of the coatings produced.



Salt spray tests show effectiveness of coatings produced by Cold Bonderite System.

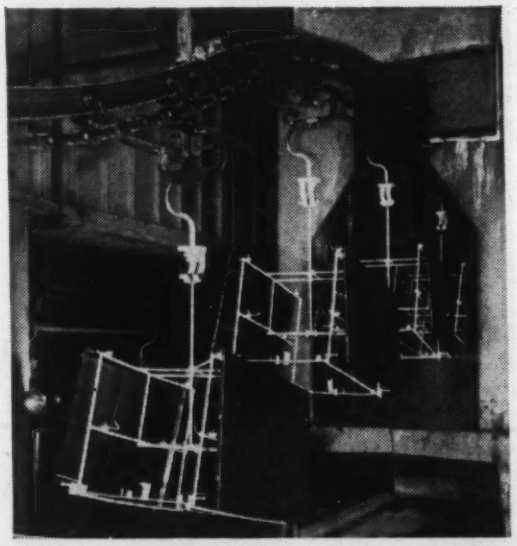
This is a thoroughly tested and proven system. The Cold Bonderite System is in use right now in many plants in many industries. And more are changing to it as they hear about the spectacular savings.

- A large automotive plant reports savings at the rate of 40 carloads of coal per year.
- An appliance manufacturer says the Cold Bonderite System is saving 5¢ per cabinet.
- Another manufacturer shut down one of his boilers because of reduced heat requirements.
- An automotive plant is saving about 12¢ per body.

There are other operational savings besides heat when you use the Cold Bonderite System. You'll use about 25% less water. You'll save electricity because you won't need to run an exhaust fan. You'll save on maintenance. You'll cut down-time, since there's no waiting for cool-off should service be required.

There are so many benefits and advantages to the new Cold Bonderite System that you can't afford not to investigate it for *your* plant.

Call or write today!



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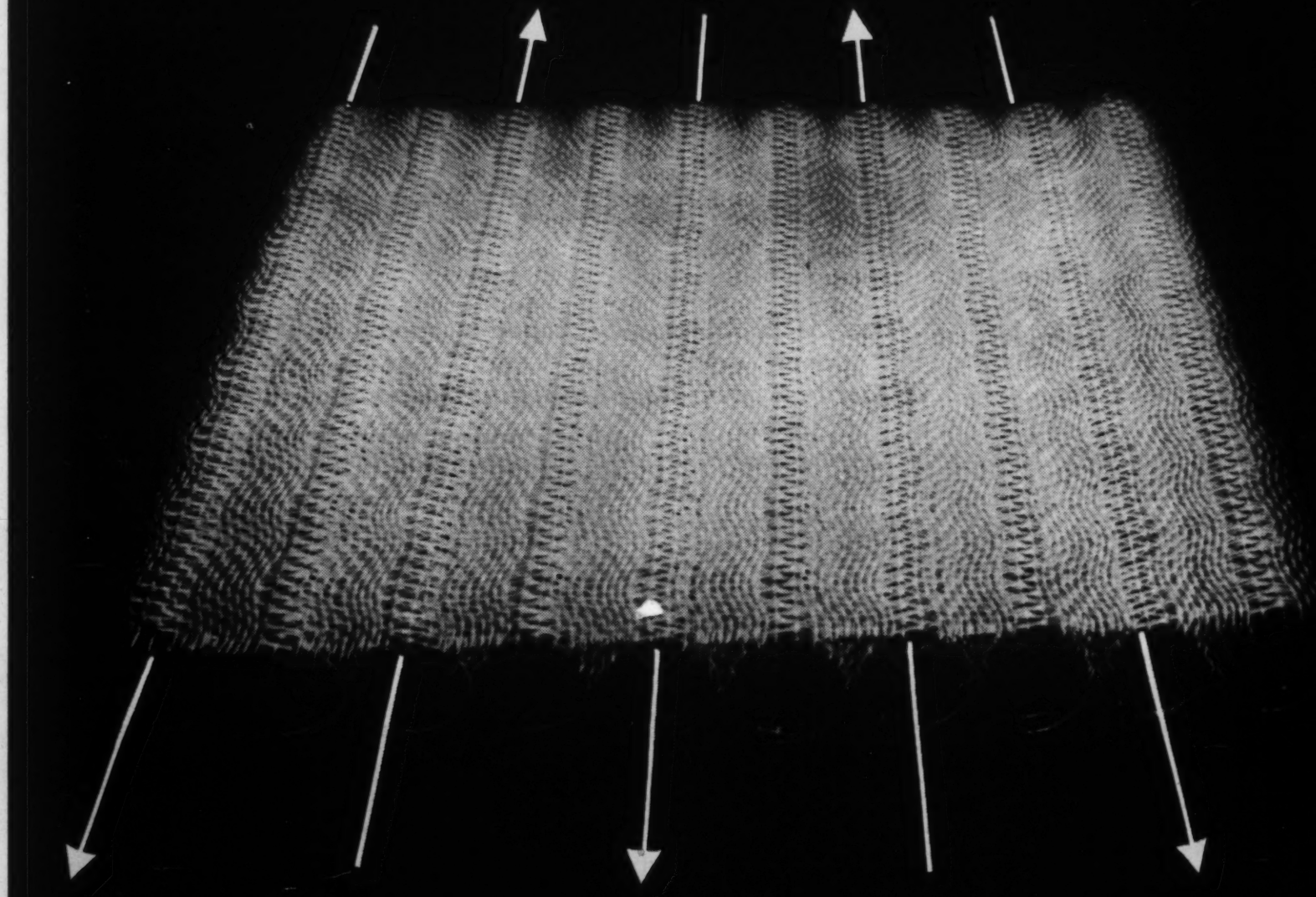
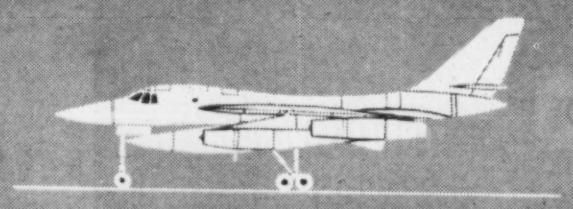


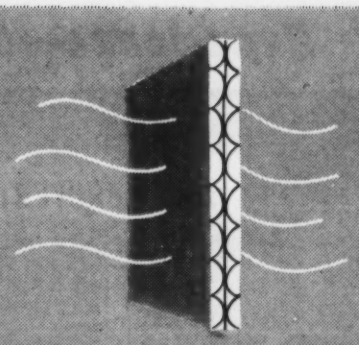
HOW CAN YOU USE TRILOK® ... THE 3-DIMENSION STRUCTURAL FABRIC WITH LATERAL POROSITY?

TRILOK'S *stabilized* 3-dimensional form is produced by employing differential shrinkage between polyethylene fibers and Saran® or nylon fibers in the weave. First used for upholstery, TRILOK—*in new forms*—is now finding wide use throughout industry. *Lateral porosity* is one reason. Under extremely low back-pressure, air, liquid or extra-fine particles can pass through TRILOK, which greatly resists compression and "pinching-off". In addition, because of its cushioning properties, TRILOK is often specified for shock-absorbing purposes. In fact, TRILOK has proved to be the answer wherever a "spacer" of very efficient volume/weight characteristics is needed.



PROTECTS WINGS AGAINST HAILSTORMS

With TRILOK wing covers protecting delicate wing structures, planes can be parked in the open and serviced by "wing-walkers". Porosity of the fabric also lets water drain easily.

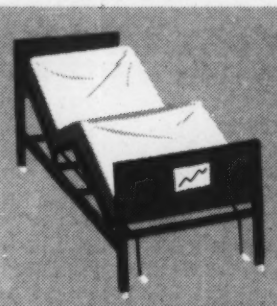


ENDS METAL WIRE RUST IN FILTERS

TRILOK, in any of eight standard weaves, is an extremely efficient filter material; has none of the drawbacks of metal bases which corrode during passage of various "batches".

VENTILATES PROTECTIVE GARMENTS

Besides offering protection, TRILOK helps keep personnel comfortable. Heated or cooled air can be passed through the garment and perspiration evaporates naturally.



RELIEVES BED IRRITATIONS

A bed-pad of TRILOK allows a constant stream of fresh, healthful air to cool the patient's skin; prevents excessive moisture build-up through natural evaporation.

MAKES SEAT CUSHIONS SELF-VENTILATING

With a TRILOK seat-section, air can move freely beneath the body. All areas experience the same temperature sensation, excessive "spot" perspiration build-up is prevented.

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In literally hundreds of laboratory and field experiments ranging from acoustical applications to medical-treatment procedures, TRILOK is proving a most versatile fabric.

THESE TRILOK PROPERTIES MAKE NEW DESIGN IDEAS PRACTICAL!

- High degree of resistance to all chemicals
- Does not mildew or corrode
- Excellent tensile strength and abrasion resistance
- Is lightweight per unit of thickness
- Excellent recovery and resiliency properties
- Can be engineered, to exhibit more pronounced resistance to compression and shock
- Fabrics are available in eight standard weaves and range in thickness from 1/10" to $1\frac{3}{16}$", from smooth double-faced fabrics through single- and double-faced textures

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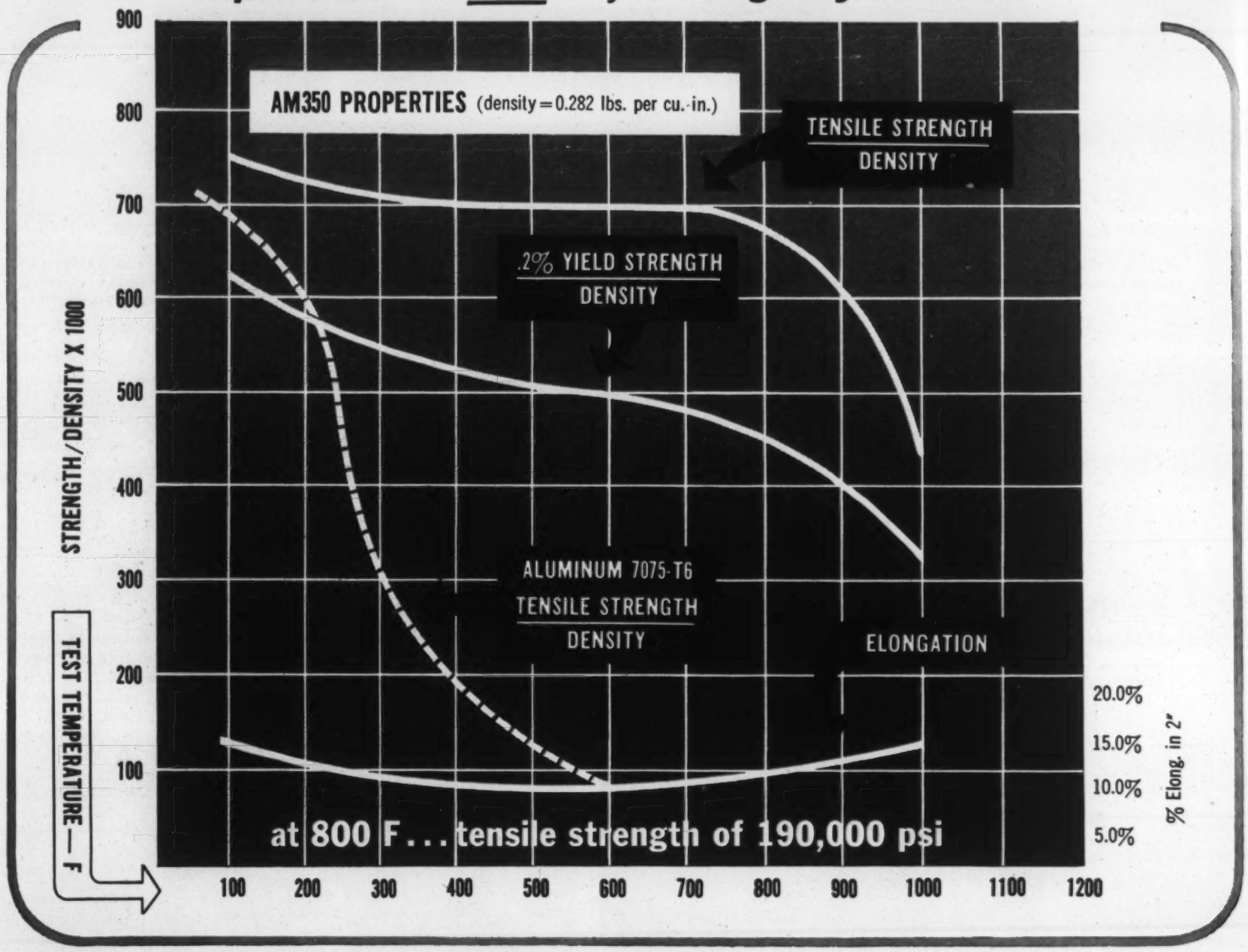

Here are the facts on AM350 and AM355, Allegheny Ludlum's precipitation hardening stainless steels

A unique combination of highly desirable properties is the usual description of Allegheny Stainless AM350 and AM355 Steels. They combine high strength at both room and elevated temperatures, excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

They are proving the answer to many problems of the air age. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM350 and AM355.

Availability: AM350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM355, best suited for heavier sections, is available in forgings, forging billets, plate, bar and wire.

Corrosion resistant: Being stainless steels, these alloys resist corrosion and oxidation. Compared to the older, more familiar stainless grades, their corrosion rating is better than the hardenable grades (chromium martensitic) but generally less than the old corrosion resistant standbys, the 18 and 8's. Stress corrosion is resisted at much higher hardness levels than with martensitic stainless.

Simple heat treatment: High strength is developed by two methods, both involving less than ordinary temperatures and minimizing oxidation and distortion problems. The most popular, and one that develops slightly better properties, is the Allegheny Ludlum developed sub-zero cooling and tempering (SCT condition). The material is held at minus 100 F for 3 hrs plus 3 hrs at 850 F. Alternate method is Double Aged (DA): 2 hrs at 1375 F plus 2 hrs at 850 F.

Easy fabrication: AM350 and AM355 can be spun, drawn, formed, machined and welded using similar procedures as with the 18-8 stainless types. In the hardened condition (SCT & DA) some forming may be done . . . 180 degree bend over a 3T radius pin. Also it can be dimpled in the hard condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.* Address Dept. MM-12.

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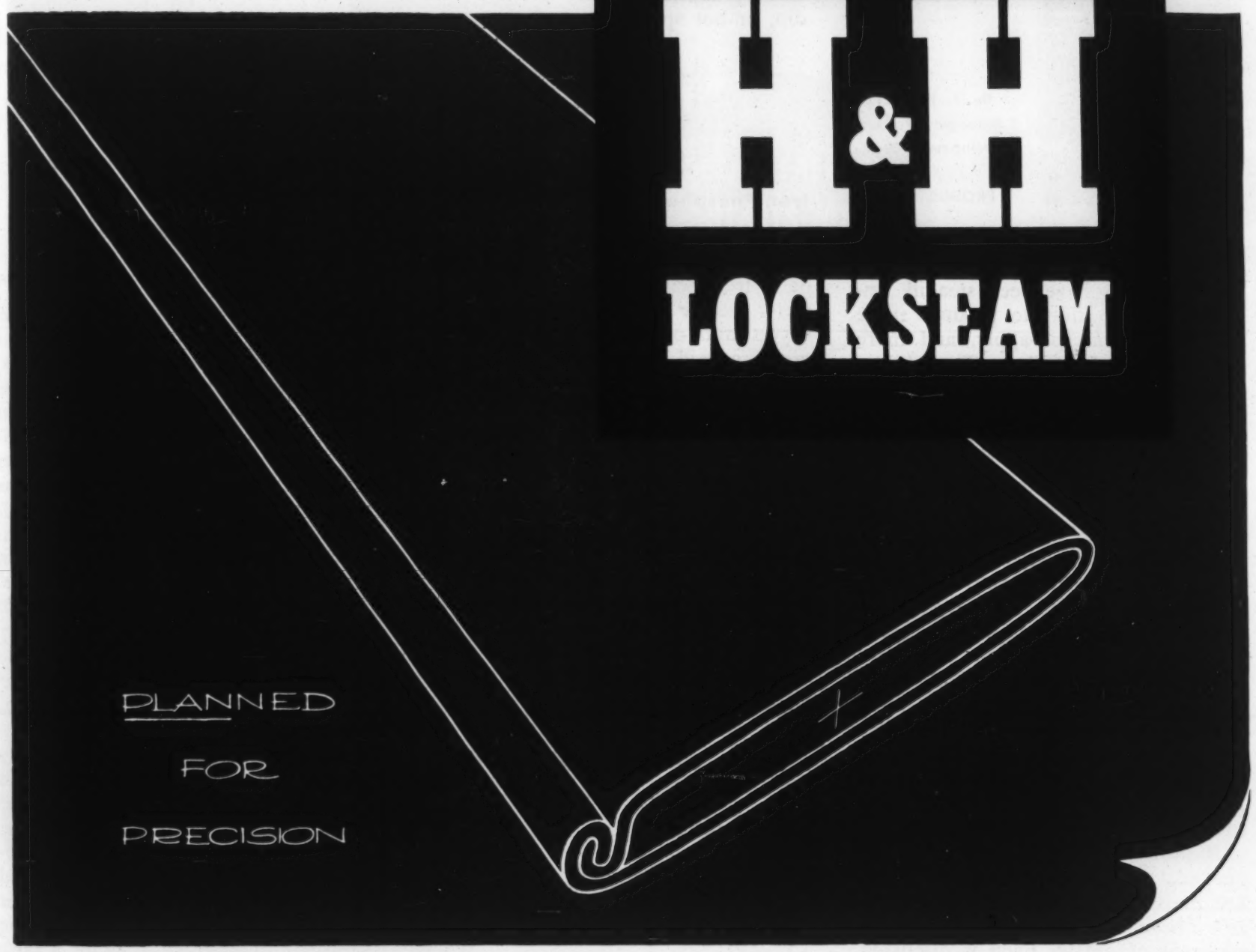

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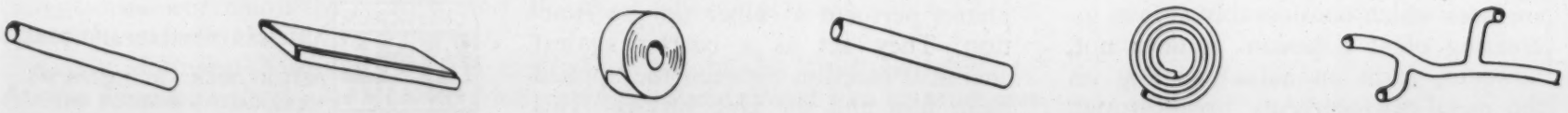

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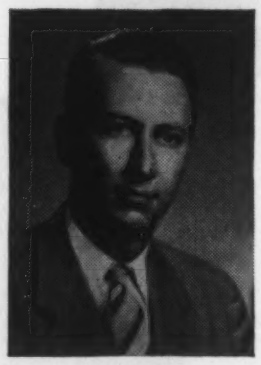
Chemical Prepaint Treatments for Metal Surfaces

What they do, the types available, how they are applied



By J. H. GEYER
Manager, Product Development Dept.,
AMCHEM PRODUCTS, INC.

Paint systems have been steadily improved in an effort to produce more decorative, easier-to-apply, and more corrosion-resistant films. The ability, however, of any paint film to perform its predetermined functions cannot be fully utilized without properly preparing the metal surface.

The prepaint preparation of the metal surface is therefore a highly important part of the system. Chemical prepaint treatments are designed to do four jobs and do them well. First, they remove organic soils, shop dirt, scale, and rust or corrosion products from the metal surface. Second, they provide surfaces that are completely compatible with subsequent paint films. Third, they produce a *tooth* that promotes good paint film adhesion. Fourth, they effectively prevent underpaint corrosion growth after any breakthrough in the paint film.

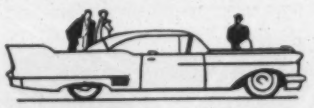
Basically, there are four types of chemical prepaint treatments. These are phosphoric acid, iron phosphate, zinc phosphate, and amorphous phosphate or chromate. Each is discussed briefly in the following paragraphs.

Phosphoric Acid

Perhaps the most widely used and certainly one of the most economical chemical prepaint treatments is the phosphoric acid cleaner combination materials. ACP Deoxidine® is such a material. It removes organic soils, rust, scale and contaminating elements from the metal surface. It also produces a light etch on steel, aluminum or zinc surfaces which considerably aids in increasing paint adhesion. It does not, however, form an actual coating on the metal surface. Any breakthrough in the subsequent paint film will permit underfilm corrosion to proceed. Grades of Deoxidine are available for application by brush or swab, hot and cold dip, or hot spray.

Iron Phosphate

Iron phosphating processes are extensively used in the chemical prepaint treatment of appliances such as water heater shells, ranges, washers, dryers and other *white lines*. These processes will produce excellent paint-bonding films on the metal and retard or prevent underpaint corrosion. Duridine,® ACP's iron phosphating process, is a combination organic soil cleaner and iron phosphate coating material. Both the cleaning and coating operations take place in the same bath. Duridine and other iron phosphates do not lend themselves to brush-on application, are primarily designed for spray type equipment of four or five stages. But several dip installations are successfully operating today by inclusion of an alkali precleaning stage.



Zinc Phosphate

ACP Granodine® is an example of this type of chemical prepaint treatment process, the type now being used to treat steel in the automotive industry, and predominantly specified for steel ordnance and military items. This process forms a coating which offers the ultimate in paint adhesion promotion and vastly augments the corrosion resistance of subsequent paint films. Zinc phosphate materials are extremely flexible as to method of application—can be applied by brush, dip or automatic spray equipment. In a typical dip or power spray system, the stages would be alkali clean, water rinse, zinc phosphate treatment, water rinse, and acidulated final rinse. If the metal has considerable areas of rust or scale, an acid pickle is advisable following the alkali cleaning stage.

On zinc surfaces, the zinc phosphates perform a rather unique function. They act as a barrier against chemical reaction between the applied paint film and the zinc surface. This effectively prevents blistering of the paint and early breakdown of the film. This is in addition, of course, to the improvement of paint adhesion and the retarding of underpaint corrosion. ACP Lithoform® is specially designed for use over zinc surfaces and finds wide application as a prepaint treatment for ornamental zinc die castings, refrigerator liners, and on most galvanized work requiring painted finishes.

Amorphous Phosphate and Chromate

These coatings are the films produced by the ACP Alodine processes and similar ones on aluminum surfaces. They have met with wide acceptance in the prepaint treatment of venetian blind strips, refrigerator liners, aluminum heat transfer units, aircraft sheet metal assemblies, and many other items fabricated from aluminum. The various coatings provide an excellent film for the promotion of paint adhesion and effectively prevent underfilm corrosion. As in the case of zinc, aluminum exhibits a tendency to chemically react with some paint systems. The Alodine processes develop a barrier film between the paint and the aluminum surfaces which prevents this reaction. The Alodines are extremely versatile materials that can be applied to aluminum surfaces by brush, hand spray, dipping, mechanical spraying, or roller coating equipment. Brush application is particularly well adapted to the processing of parts too large for simple dip systems or in manufacturing operations that do not warrant a tank setup. In dip, spray or roller coating application, the system usually consists of an alkaline preclean, a water rinse, the Alodine treatment, a water rinse, and an acidulated final rinse. Where the surface is heavily oxidized, a deoxidizer in the line is needed.

The major chemical prepaint treatments for metals have been covered briefly in this article. More complete information can be had by contacting an ACP sales representative or by writing us at Ambler, Pa.

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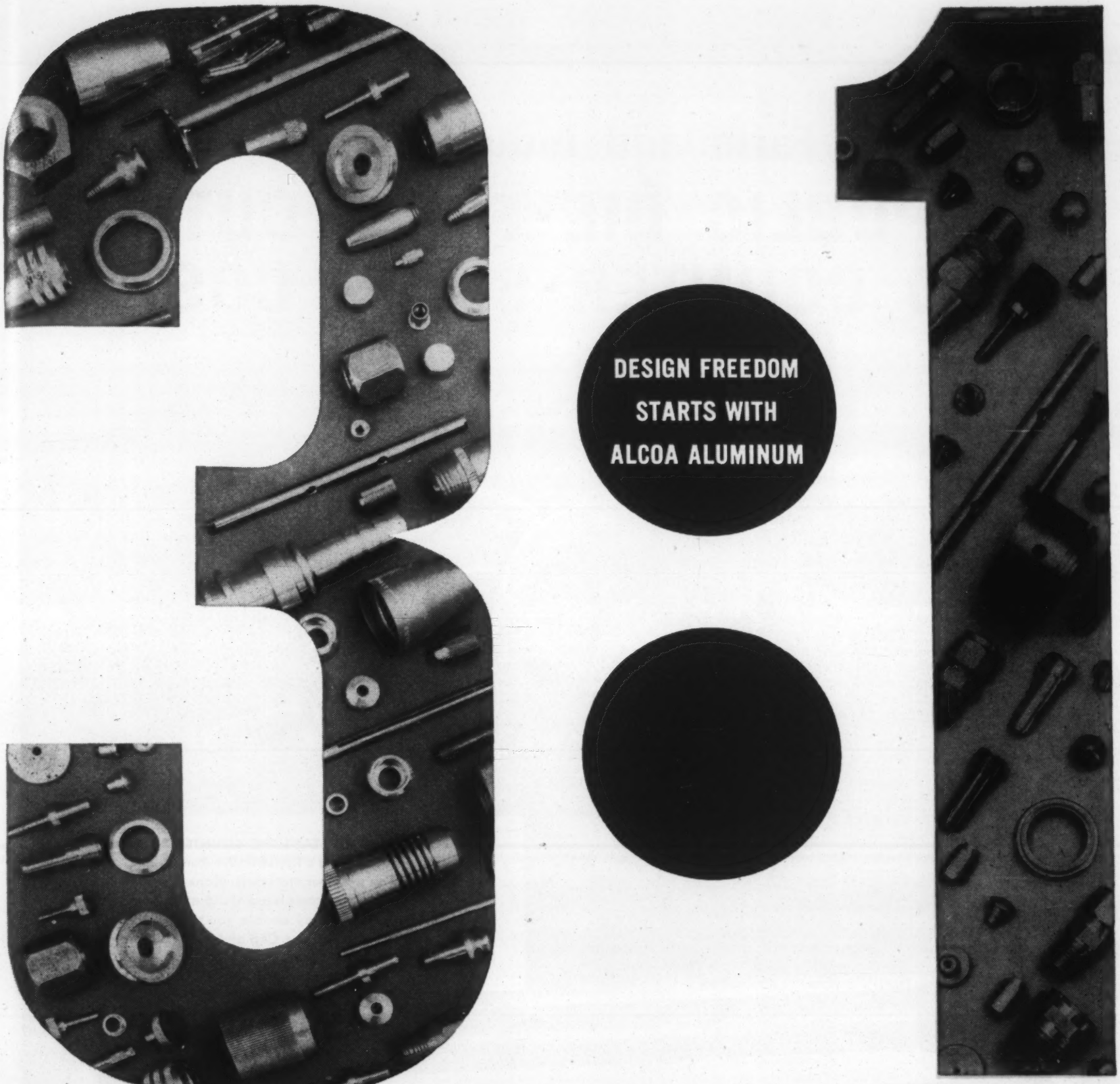

DOES YOUR DESIGN CALL FOR SCREW MACHINE PARTS?

Cut costs with ALCOA® Aluminum. It gives three times more parts per pound because it weighs only a third as much as steel or brass. Add aluminum's high scrap value . . . and you can save up to 30 per cent in material costs alone.

Light weight also adds design freedom. ALCOA Aluminum Screw Machine Stock helps you cure inertia problems without sacrificing strength or performance. Moving parts wear less because there's less resistance to applied force. Designers of automotive parts, business machines, ordnance, have proved it.

Aluminum offers exceptional machinability, limited almost entirely by machine capacity . . . high electrical and thermal conductivity . . . and choice of any finish, including lustrous, lasting anodized color.

Aluminum is versatile. Each of ALCOA's four screw machine stock alloys has significant advantages. Specify 2011-T3 for machinability; 6061-T6 for exceptional corrosion resistance and finishing characteristics; 2024-T4 for strength; and 2017-T4 for economy.

Argus, Johnson Motors, Leviton and other companies that switched to ALCOA Aluminum tell why in a booklet we've prepared. We'd like to send you a copy. Just mail the coupon.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

ALCOA THEATRE
Fine Entertainment
Alternate Monday Evenings

Look for this label . . . it's your guide to the best in aluminum value

Aluminum Company of America
869-M Alcoa Building, Pittsburgh 19, Pa.

Please send your new booklet about the switch to Alcoa Aluminum Screw Machine Stock.

Name_____

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In *Ford* Farm and Industrial Tractors...

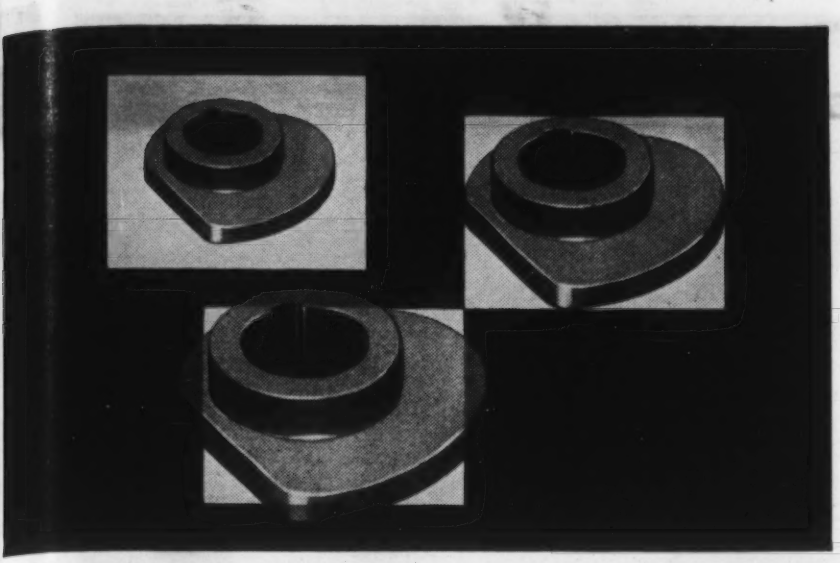
REPUBLIC DIE-FORM CUTS PTO COUNTER-SHAFT COST

FORD TRACTOR POWER TAKE-OFF COUNTER-SHAFT costs less to produce using a Republic Die-Form blank, as compared with previous materials. Blank is shown immediately below . . . completed shaft at bottom. Use of Die-Form blanks may enable you to produce a superior part for less money. Clip and send coupon for facts.

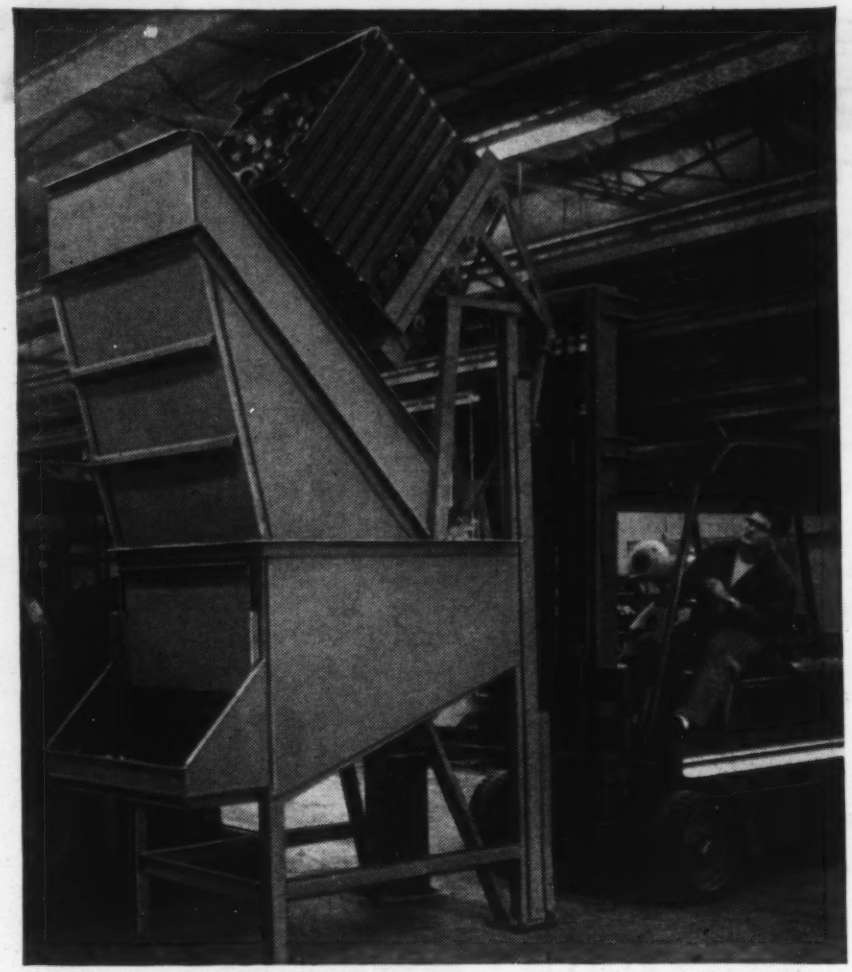
By using Republic Die-Form blanks to produce power take-off counter-shafts, Ford engineers gain substantial production economies. Because they closely approximate the completed part, Die-Form blanks minimize required machining and reduce handling costs for raw material and scrap disposal. In addition, the nature of the Die-Form Process actually improves machinability of any given steel analysis, permitting further savings through use of higher speeds and feeds.

The Republic Die-Form Process is a cold work operation performed by forcing one or more sets of dies over each end of a hot rolled steel bar. Resulting multi-diameter bar, in addition to the cost-saving advantages outlined above, offers improved yield and ultimate strength. Diameters are accurate to within .005 inches which may, in some cases, entirely eliminate further finishing.

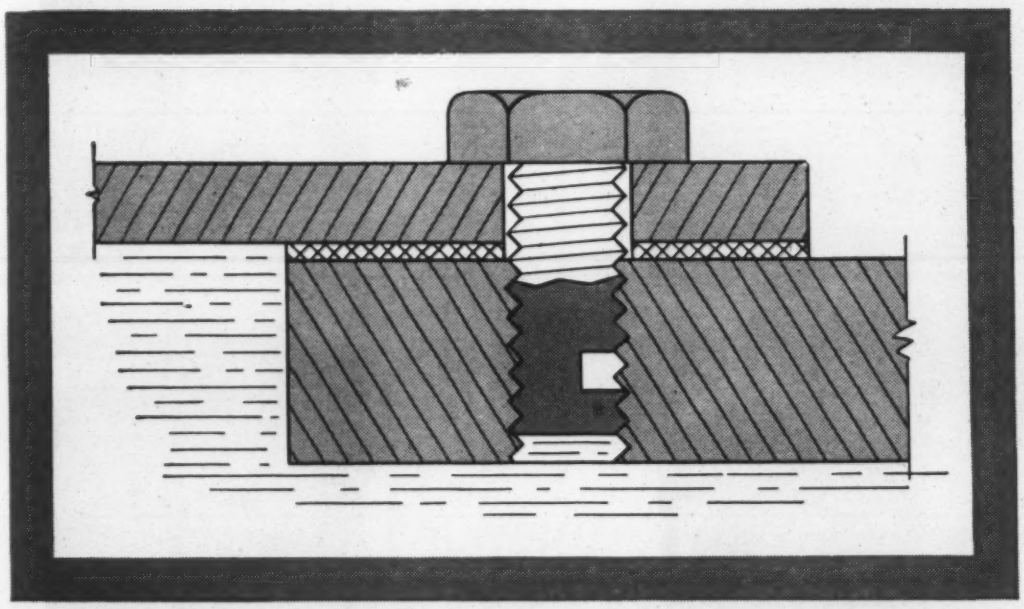
If you mass produce multi-diameter machine shafts it will pay you to investigate the savings potential of Republic Die-Form. Your nearest Republic office can provide details. Or write for Die-Form Folder ADV-746.



REPUBLIC IRON POWDERS with Controlled Dimensional Factor give your parts predictable dimensional characteristics after sintering. CDF means that in the presence of copper, Republic Iron Powder—depending on type—can be made to grow, shrink, or remain stable within acceptable tolerance limits. Tool engineers can design tools to part-print dimensions with the assurance that tolerances, transverse to the direction of pressing, can be held within ±.001 inches per inch. Fabricators can produce consistently uniform sinterings at faster rates and at minimum cost. Republic Booklet Adv-763 contains complete details. Send coupon for your copy.



REPUBLIC BOX AND SKID UNITS PERFORM FOUR JOBS, CUT HANDLING COSTS 10% at Dresser Industries' new pipe fittings plant at Wellsboro, Pennsylvania. Four functions are: (1) delivery of semi-finished parts to production stations; (2) feeding parts to machines via special hoppers; (3) receiving finished parts; (4) storage for shipment. In addition to immediate cost savings of 10%, Republic's rugged, corrugated steel construction assures years of minimum maintenance service. Send for data on Republic Materials Handling Equipment.



LIQUID SEALING PERFORMANCE is an added benefit of Republic Self-Locking Nylok® Bolts. As shown here, the nylon pellet in compression tends to expand and interrupt space between non-loadbearing surfaces of mating threads when bolt is wrenched tight. Fluid escape along helical thread path is blocked. Nylon pellet resists aging, moisture, and ordinary solvents to provide a long-lasting seal. Send coupon for information on all the benefits of Republic Nylok Fasteners.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. ME-5633-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

☐ Please send Republic Die-Form Folder ADV-746
Please send more information on:
☐ Materials Handling Equipment
☐ Nylok Fasteners ☐ Iron Powder

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Company_____

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one million pounds of vacuum induction melted alloys per month

That's the pouring capacity of our New Hartford plant! Expanded new facilities, together with precision melting and inspection practices, enable us to guarantee absolutely consistent quality from heat to heat. For information on ingot, billet, bar, sheet, strip and wire now available in commercial quantity, write
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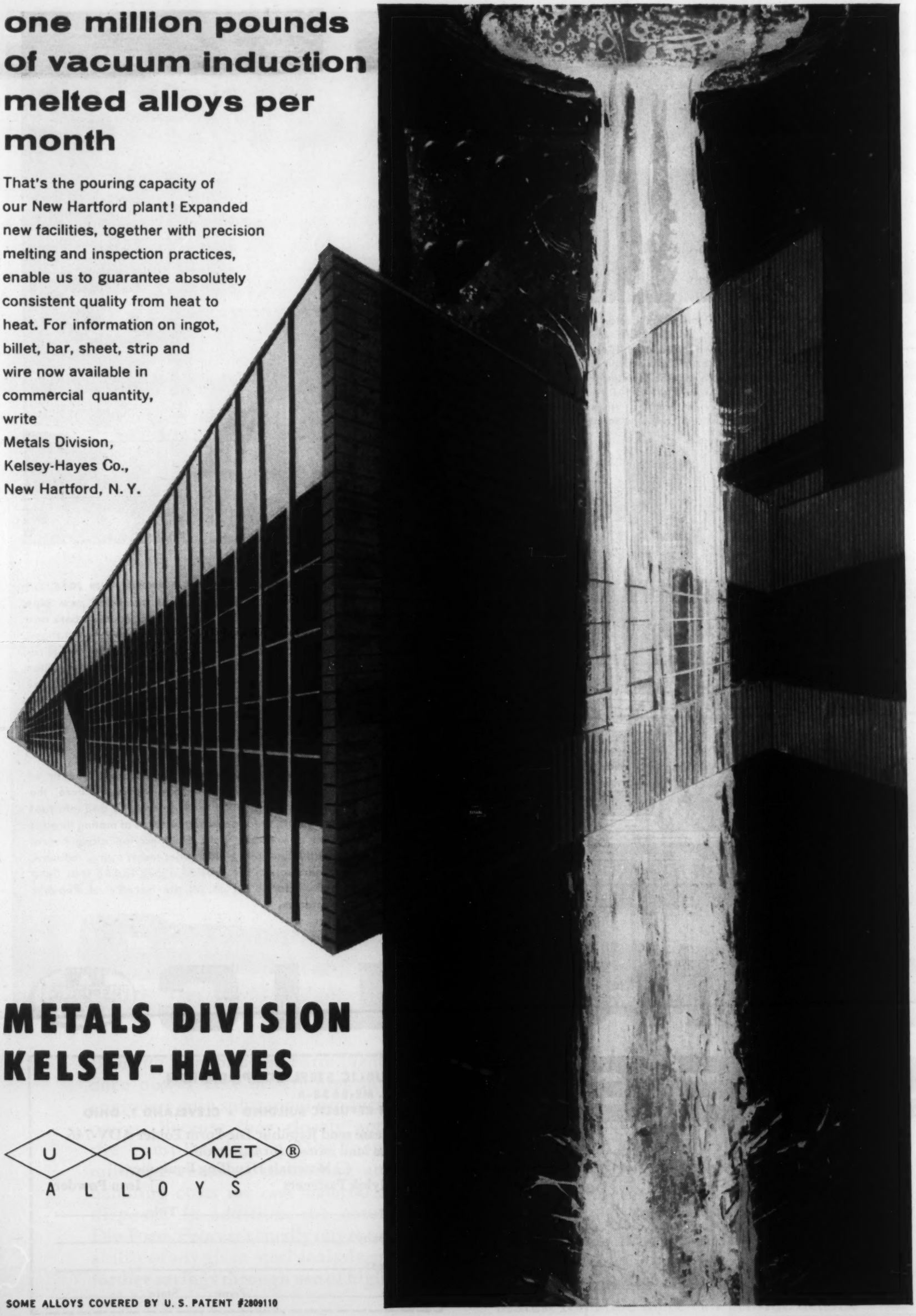
Kelsey-Hayes Co.,
New Hartford, N. Y.



METALS DIVISION KELSEY-HAYES

U DI MET® ALLOYS

SOME ALLOYS COVERED BY U. S. PATENT #2809110

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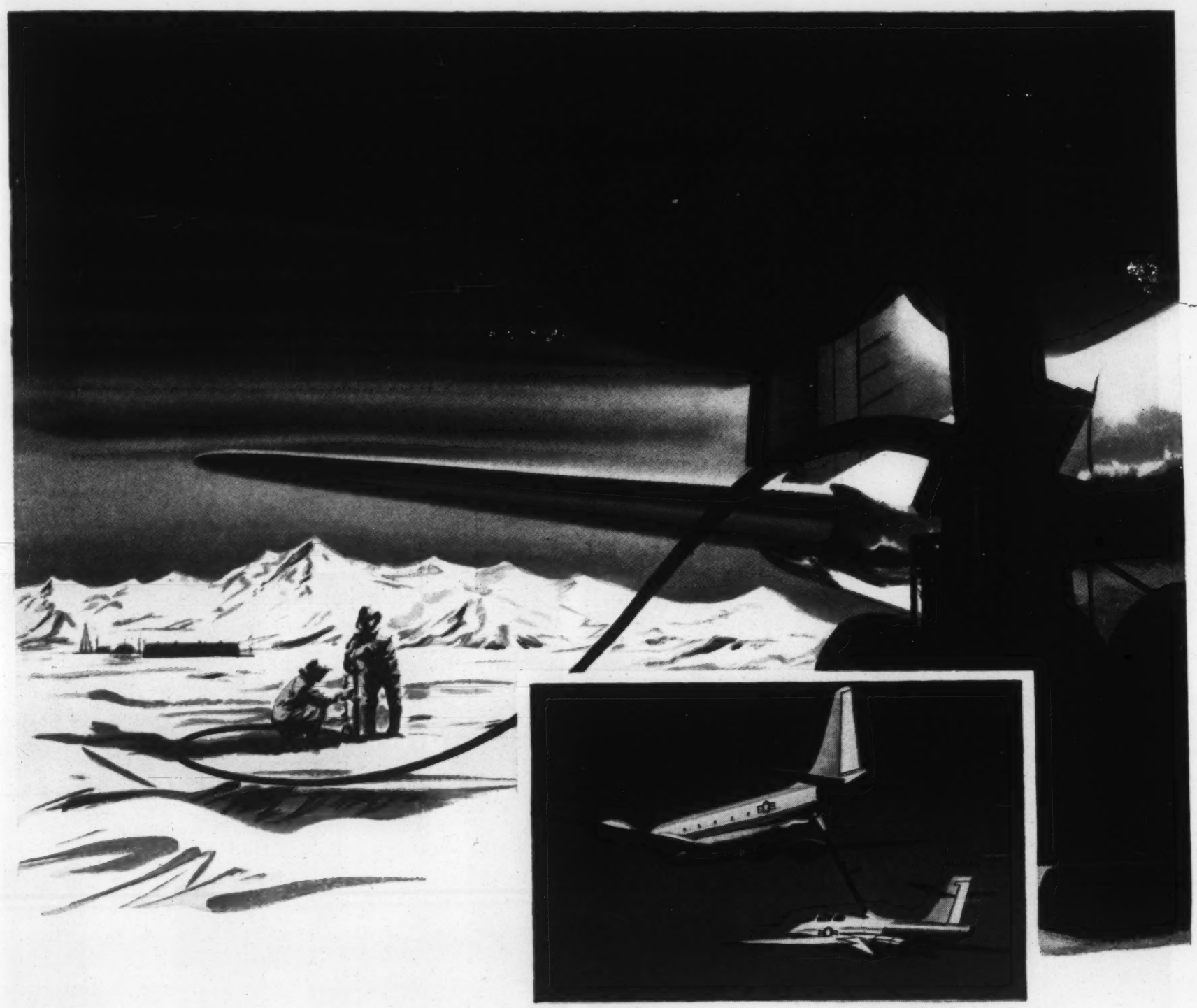

Flexibility at extreme low temperatures

with THIOKOL® PLASTICIZER TP-90B

Gassing up aircraft in the deep freeze of the frigid zone . . .

. . . refueling on the wing in the sub-zero temperature of high altitudes . . .

. . . it takes unique rubber hose to keep flexible in such extremes of cold.

Leading hose manufacturers achieve the low temperature resistance needed by combining THIOKOL plasticizer TP-90B with selected types of elastomers.

THIOKOL plasticizer TP-90B is highly compatible with all elastomers and imparts flexibility which remains unaffected at extremely low temperatures. For further details, send the coupon.

FOR MORE INFORMATION:
Mail coupon to Dept. 42, Thiokol Chemical Corp., 780 N. Clinton Ave., Trenton, N. J. In Canada: Naugatuck Chemicals Division, Dominion Rubber Co., Elmira, Ontario.

Gentlemen: Please send me further details about plasticizer TP-90B.

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Thiokol®
CHEMICAL CORPORATION

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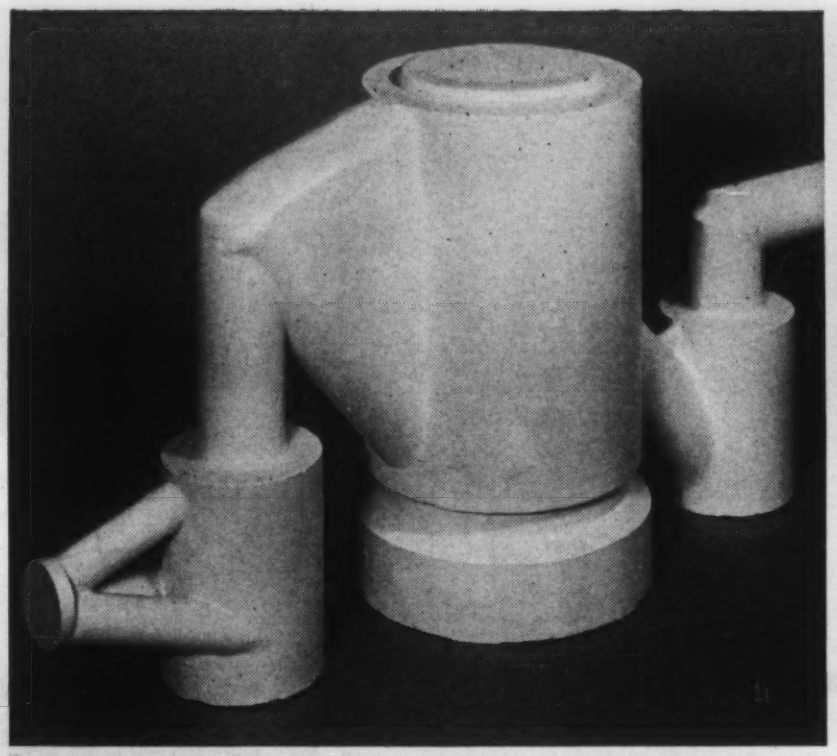
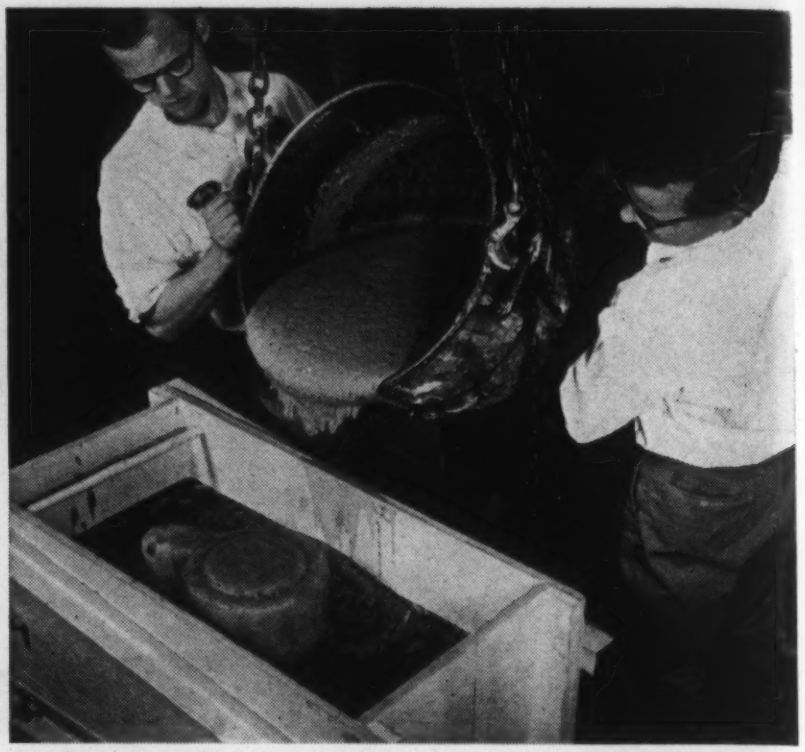
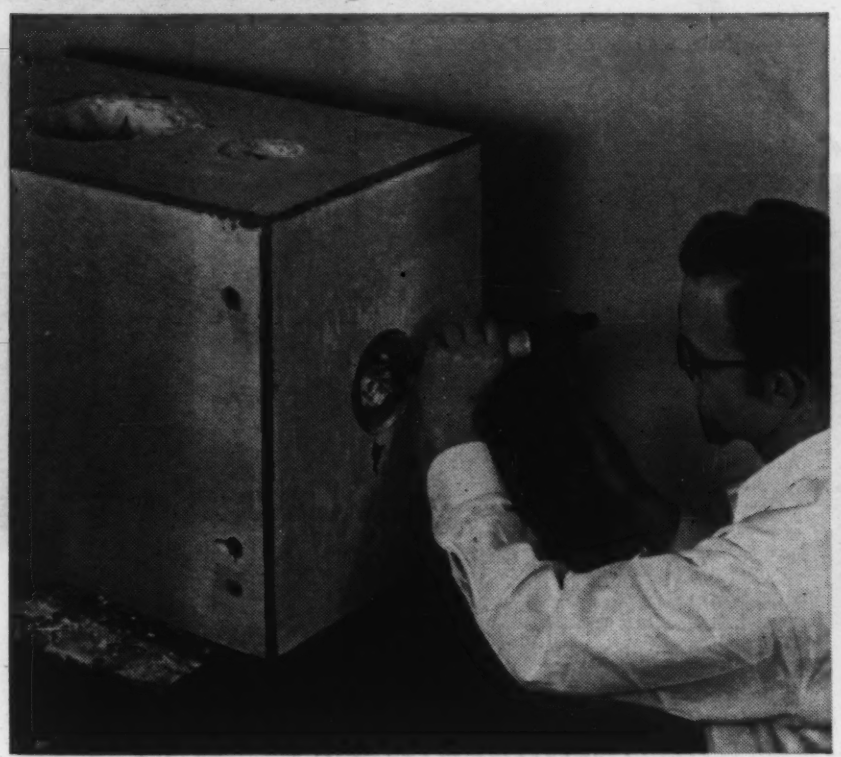


To shape the inside of the bromide-bromine liquor pump block, a form is made of plaster of Paris and Styrofoam®.



Dow Epoxy Resin 331 (casting formulation supplied by Ren Plastics, Inc.) is poured over the form and hardens.



The plaster of Paris and Styrofoam material in the form is broken up and removed.

Main part of bromine pump is installed, ready to operate without wear or corrosion!

Dow Epoxies help stop corrosion for chemical processors

This corrosion-free pump block adds another to the list of success stories made possible by new, pure Dow Epoxy Resins.

For years the main parts of bromide liquor pumps have been made with machined soapstone. Performance was inconsistent; the slightest crack or seam proved disastrous. But now Dow Epoxies open a new era of efficiency and economy for the chemical processing and corrosion fields. Easily cast to shape without costly machining, the epoxy pump blocks are impervious to the chemicals involved and free from the internal flaws of soapstone.

Have you a corrosion problem where Dow Epoxies may help? Write for information and technical help. Dow is a basic producer of the raw materials used in epoxy production. In this way Dow provides raw materials with optimum properties to produce superior resins, to control quality carefully and to provide a narrower range of specifications in the finished resin—so necessary to uniform performance. For complete information and technical data on Dow Solid and Liquid Epoxy Resins, consult your Dow sales office. Or write THE DOW CHEMICAL COMPANY, Midland, Michigan, Coatings Sales Department 2265L-1.

EPOXY T.M.

YOU CAN DEPEND ON DOW

For more information, turn to Reader Service Card, circle No. 379

brighten homes, brighten sales with life-long beauty

UNILOY
STAINLESS STEELS

The gleaming beauty, plus the permanence and ease of cleaning have made stainless steel the wife's delight—and sold many a home.

When made from Uniloy stainless steel, flatware, utensils, and other kitchen accessories have that inviting blend of beauty and permanence so appealing to the modern homemaker.

Uniloy stainless steels—easy to work and form—are rolled to most exacting specifications by steel makers who have been making specialty steels since 1884.

UNIVERSAL CYCLOPS
STEEL CORPORATION
BRIDGEVILLE, PA.

STAINLESS STEELS • TOOL STEELS • HIGH TEMPERATURE METALS

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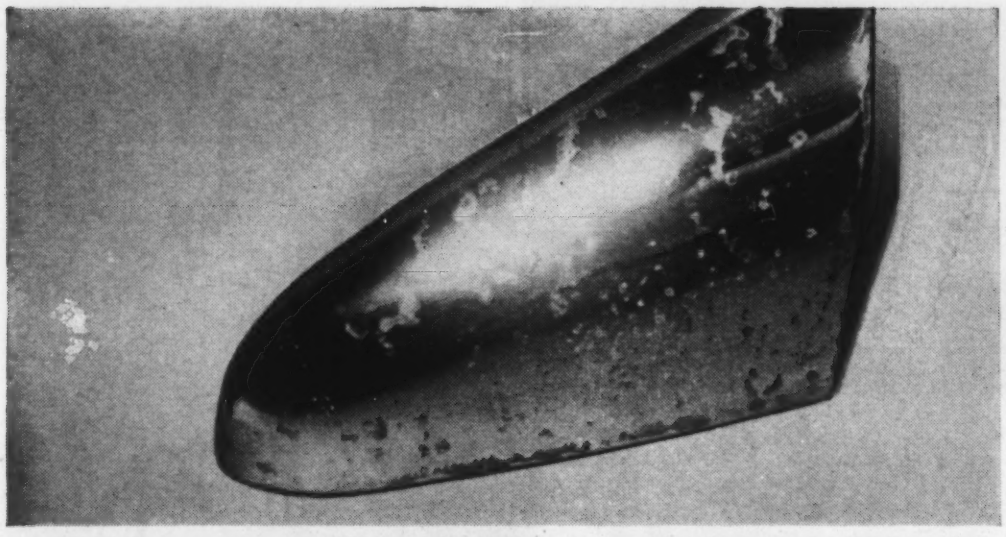
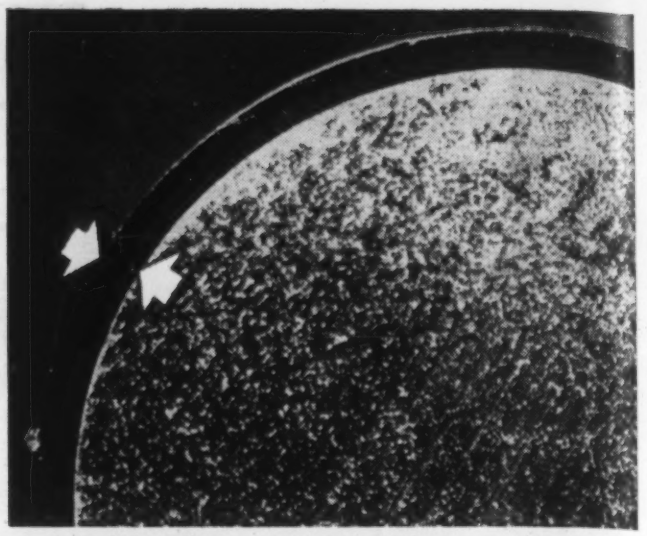
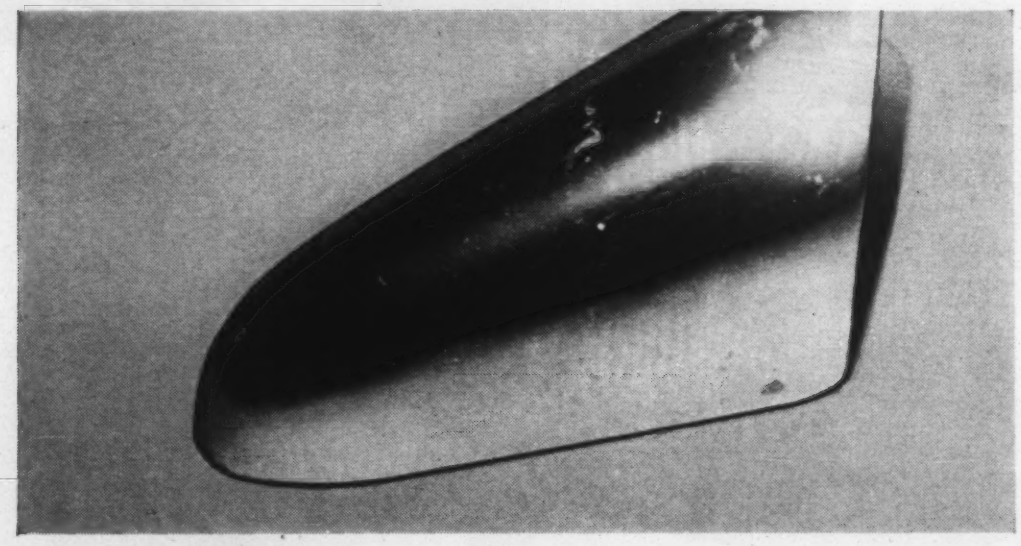
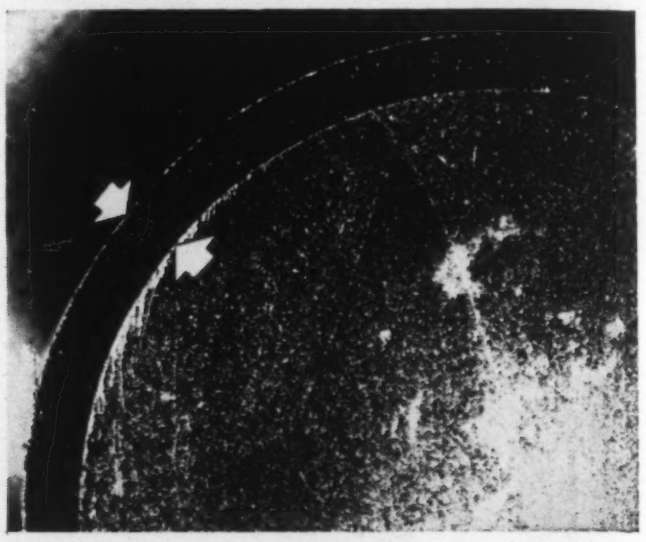


UNICHROME BRIGHT CRACK-FREE CHROMIUM MADE THIS DIFFERENCE IN PROTECTION. Photographs show results of 72 hour acetic acid salt spray test. Part at top was plated with ordinary chromium according to automotive manufacturer's specifications for copper, nickel, chromium finishing. Part at bottom had same copper and nickel deposits but Unichrome Crack-Free Chromium replaced the ordinary chromium, thus greatly increasing corrosion resistance.



UNICHROME SRHS® CHROMIUM MADE THIS DIFFERENCE IN THICKNESS. Enlarged cross sections of identical steel rods show ratio of thickness of plate from ordinary chromium solution (top) to thickness from SRHS Chromium Solution (bottom) . . . a much thicker deposit in the same plating time!





How to get more corrosion resistance from chromium plate

When consumers find fault with decorative chromium plate, it's generally due to early corrosion.

This trouble starts with pores and cracks that occur in all ordinary chromium in the range of thicknesses generally used for decorative plating. Road chemicals, salt atmosphere and fumes find a path right down to base metal. Corrosion starts. As corrosion increases, finish failure progresses, allowing still more corrosion.

But you can stop this at the source.

THICKER, CRACK-FREE CHROMIUM

Chromium itself is passive. It doesn't corrode. Eliminate pores and overcome its cracking and you greatly improve its corrosion *protection*. Pores are eliminated by thicker plating. To overcome cracking, use the Unichrome Bright *Crack-Free* Chromium Process. This deposit is free from corrosion-admitting cracks. It has already been used in automotive production for a year.

MINIMIZE PRODUCTION PROBLEMS

Unichrome *Crack-Free* Chromium is far superior to ordinary chromium not only in protection, but also in operating advantages. The solution is self-regulating. It offers improved throwing power, also better coverage — even over passive nickel.

TO PLATE THICKER CHROMIUM

For those who desire thicker deposits but do not require freedom from cracking, other Unichrome self-regulating processes offer distinct advantages. They plate up to 80% faster than ordinary chromium plating processes. They cover parts with less dulling or burning, are less susceptible to clouding due to current interruption. Control is simplified by their self-regulating features.

Whichever process is best for your products, Metal & Thermit has over 30 years of service experience to help you make it work. Call in an M&T plating engineer to survey your requirements, tell you what's needed for the results you want. Or, send for Bulletins.

METAL & THERMIT
CORPORATION

GENERAL OFFICES: RAHWAY, NEW JERSEY
Pittsburgh • Atlanta • Detroit • E. Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, Ont.

For more information, turn to Reader Service card, circle No. 492

For more information, circle No. 479

KEYSTONE QUALITY... Quirk DESIGN make the strongest milk crates ever built!

How important is wire in the manufacture of milk crates? "Plenty!" says Casson Butcher, General Manager, Quirk Manufacturing Company, Cudahy, Wis. Here's why Quirk uses Keystone Galvanized Cold Rolling Quality Wire 100%.

- Heading quality—Quirk Bottle Saver Crates use patented double headed rods to brace the crate and prevent loosening of the bottom, corner and side channels. Keystone Wire serves this purpose perfectly.
- Uniform, zinc coating must resist daily immersion in chemical baths at the dairies, yet adhere tightly and avoid flaking from the cold rolling operation. (Flattened wire gives the necessary smooth surface for paper carton crates.)
- Weldability—clean silver brite galvanized surface on specially developed analysis of homogenous steel produces strong uniform welds.
- Easy forming—Quirk Bottle Saver Crates require high protective wire loops with slight spring action. Keystone cold rolling quality wire has the correct temper and stiffness to properly form with ease, yet retain the spring required for rough handling.

This is how another manufacturer builds a quality product —and Keystone Wire helps make it easier and more practical. It may be the answer to many of your quality control problems, too. For complete information, call your Keystone Representative. Our metallurgical staff is anxious to help solve your wire problems.

Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE WIRE FOR INDUSTRY

a wide selection...

from J&L STAINLESS and STRIP DIVISION

restricted and standard specification cold rolled strip steel

FULL LINE

Let's examine this "Full Line" product list of cold rolled strip steel. At J&L it includes all carbon grades, coated and uncoated, alloy, stainless and tempered spring steel. It offers all thicknesses from .001" or less to .156" or more, in widths from ¼" to 24"—and tolerances for gauge and width closer than standard when required. There are "Full Line" advantages, too, in a range of controlled tempers and structures possible only with the variety of annealing, heat treating and rolling processes found at J&L.

Your "Full Line" benefits can start by specifying J&L because only J&L makes standard and restricted specification cold rolled strip steel in such a wide range of analyses, grades and sizes to accurately meet the most exacting need.

For Strip Steel, call the Strip Steel Specialist — J&L.

J&L STAINLESS AND STRIP DIVISION produces a full line of restricted and standard specification strip steel in these grades and types:

Low Carbon
High Carbon
Tempered Spring Steel
Electrolytic Zinc
Alloy
Stainless

STRIP STEEL

Jones & Laughlin
STEEL CORPORATION
STAINLESS and STRIP DIVISION
YOUNGSTOWN 1, OHIO

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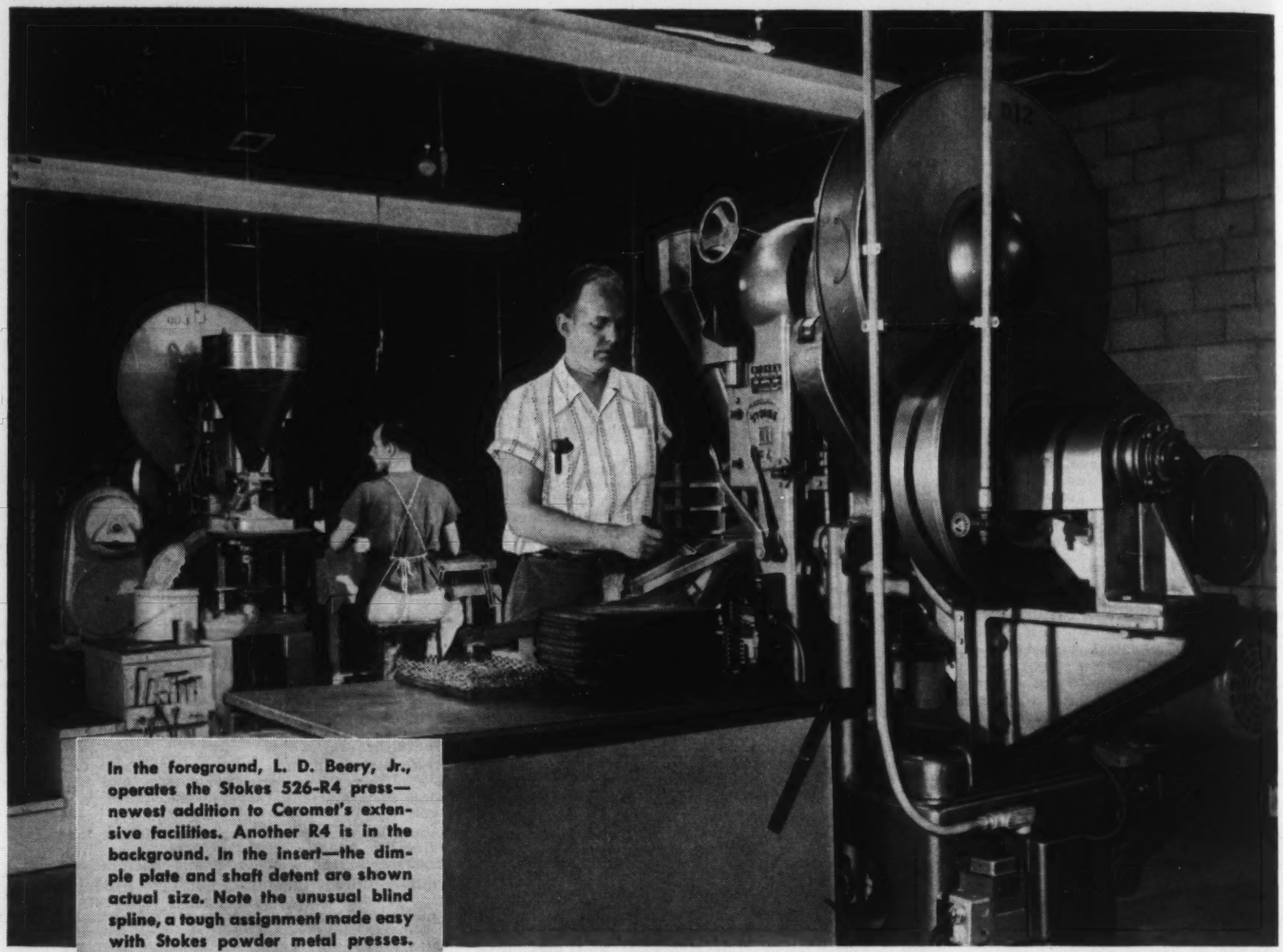

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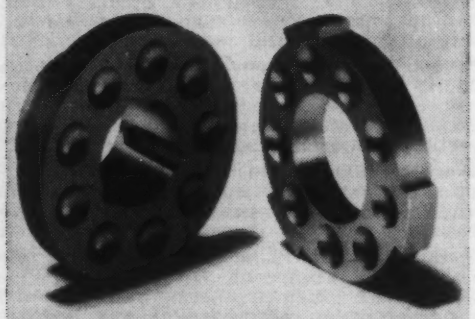

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New method of protection incorporates corrosion inhibitors in a water-soluble polymer base. Dries to an extremely thin, tough, durable coating—clear in color. Does not chemically affect base metal or any post-treatments. Used as a protective treatment alone or to enhance value of post-treatments.

Allied's new Irilac #1000 is a concentrated solution of a water-soluble polymer with built-in complex corrosion inhibiting materials. It was developed to answer the needs of the metalworking industry for a non-conversion process that will provide corrosion resistance and resistance to fingerprinting and abrasion on base metals and electrochemically or chemically finished surfaces—without changing the appearance of the metallic surface.

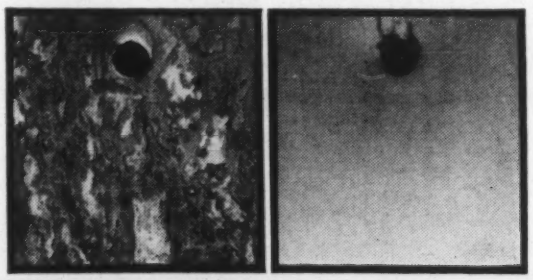
There are no hazards involved—Irilac is non-fuming, non-toxic, and requires no special fire prevention measures.

THE PROCESS

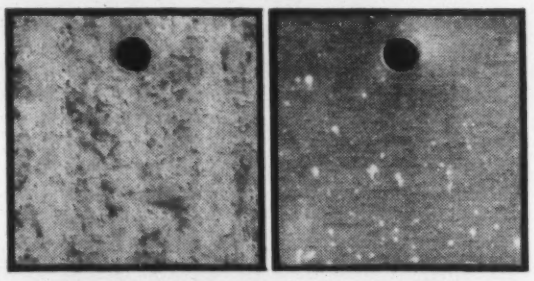
Irilac #1000 is diluted with water to provide a simple one-pass working solution. It is then applied by dip, brush or spray and forms a coating that quickly *bonds* to the metal surface without reacting with the surface.

THE PROPERTIES

The resulting coating is clear, transparent, thin yet durable. It has excellent water-resistant properties, and can be rubbed, handled and subjected to rough treatment. The surface to which Irilac has been applied is not altered—in fact, the transparent coating brings full tone to colored surfaces and clarity to iridescent surfaces. The water-thin physical characteristic of the solution means that the coating provides protection in recessed areas that are difficult, if not impossible, to protect with other methods.



STEEL PANELS: bare (left) and coated with Irilac (right) after 8-hour salt spray.



ALUMINUM PANELS: bare (left) and coated with Irilac (right) after 168-hour salt spray.

WHERE IRILAC CAN BE USED

Irilac #1000 can be applied to *any* metal—wet or dry—treated or untreated. All metals can be processed in *one* operation in the same solution. It can be applied in conjunction with any process—over Iridite, anodized, phosphated surfaces, black oxide, etc. Surfaces treated with Irilac provide a good base for paint.

APPLICATION ADVANTAGES

No other process or material available for the protection of metals offers all the application advantages found in new Irilac #1000:

1. It can be applied to *any* clean metal simply by dip, brush or spray. No special equipment is required.
2. Saves time—just apply and dry—no reaction time required.
3. No hazards involved—no exhaust or special fire protection equipment is required. Irilac is non-fuming and non-toxic.
4. Saves space. Presents no disposal problem. Low in first and final costs.

Because of its versatility and complete safety, Irilac has unlimited uses. For example, it will protect aluminum furniture, brass hardware and fixtures, steel parts of all types, zinc castings, etc. In fact, any base metal or plated surface, or those treated with electrolytic or chemical post-treatments, can be improved or enhanced with Irilac.

IRILAC #1000 MAY BE THE ANSWER TO YOUR PROTECTION PROBLEM

Our development staff will be glad to work with you to determine the significant benefits Irilac can offer you. Simply send us some parts and let us show you what Irilac can do. No obligation, of course.

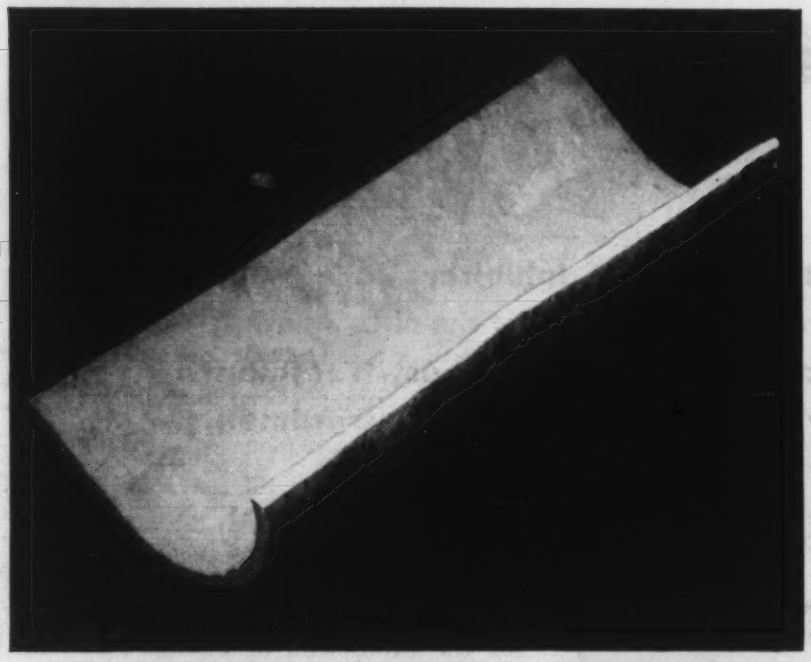
Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET
BALTIMORE 5, MARYLAND

***Manufacturers of* IRIDITE®, IRILAC™, ARP® Brighteners and Plating Chemicals**
West Coast Licensee: L. H. Butcher Co.

For more information, turn to Reader Service Card, circle No. 384

Look to L·O·F Glass Fibers for HIGH temperature insulations with LOW weight and space factors



L·O·F Glass Fibers' High Temperature Insulations are available in strong felted sheets (3/16" or ½" thick) or bulk form.

MICRO-QUARTZ®

Insulation for temperatures in the order of 2000° F

Felted Micro-Quartz will withstand temperatures as high as 3000° F for short periods of exposure, and continuous exposure at 2000° F*.

GLASS MICRO-FIBERS

Insulation for temperatures up to 1000° F

Felted glass Micro-Fibers will withstand exposure to temperatures up to 1000° F*.

**except where reaction might occur with certain chemicals or materials.*

Made from extremely fine fibers, Micro-Quartz and Glass Micro-Fibers offer superior thermal conductivity, amazingly light weight and low heat capacity. The difference lies primarily in the temperature range.

They are particularily effective for:

- **equipment subjected to frequent heating cycles at high temperatures.**
- **equipment requiring maximum thermal resistance per unit thickness of insulation, and high diffusivity.**
- **portable equipment where space and weight are critical factors.**

L·O·F GLASS FIBERS

If you have a high-temperature design problem, write on your letterhead to: *L·O·F Glass Fibers Company, Dept. 37-128, 1810 Madison Ave., Toledo 1, Ohio.*

L·O·F GLASS FIBERS COMPANY TOLEDO 1, OHIO

For more information, turn to Reader Service card, circle No. 473

For more information, circle No. 480

JL STEEL STAINLESS
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ANNOUNCING

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J & L's Completely New Stainless Mill . . .
designed and engineered to give you the fastest delivery on Quality Stainless Sheet and Strip

Now you can demand the quality you need and get the service you want from the most advanced stainless steel sheet and strip source in the industry. J & L's new Sendzimir Mill at Louisville, Ohio, is the result of years of planning by specialists to provide a new facility of such perfection that yield of the highest quality is assured.

J & L can now offer stainless sheet and strip to the most exacting specifications, producing stainless sheets to extremely close tolerances in widths up to 48 inches.

By efficient, flexible scheduling and adequate inventory support, J & L offers stainless steel buyers everywhere the fastest possible service.

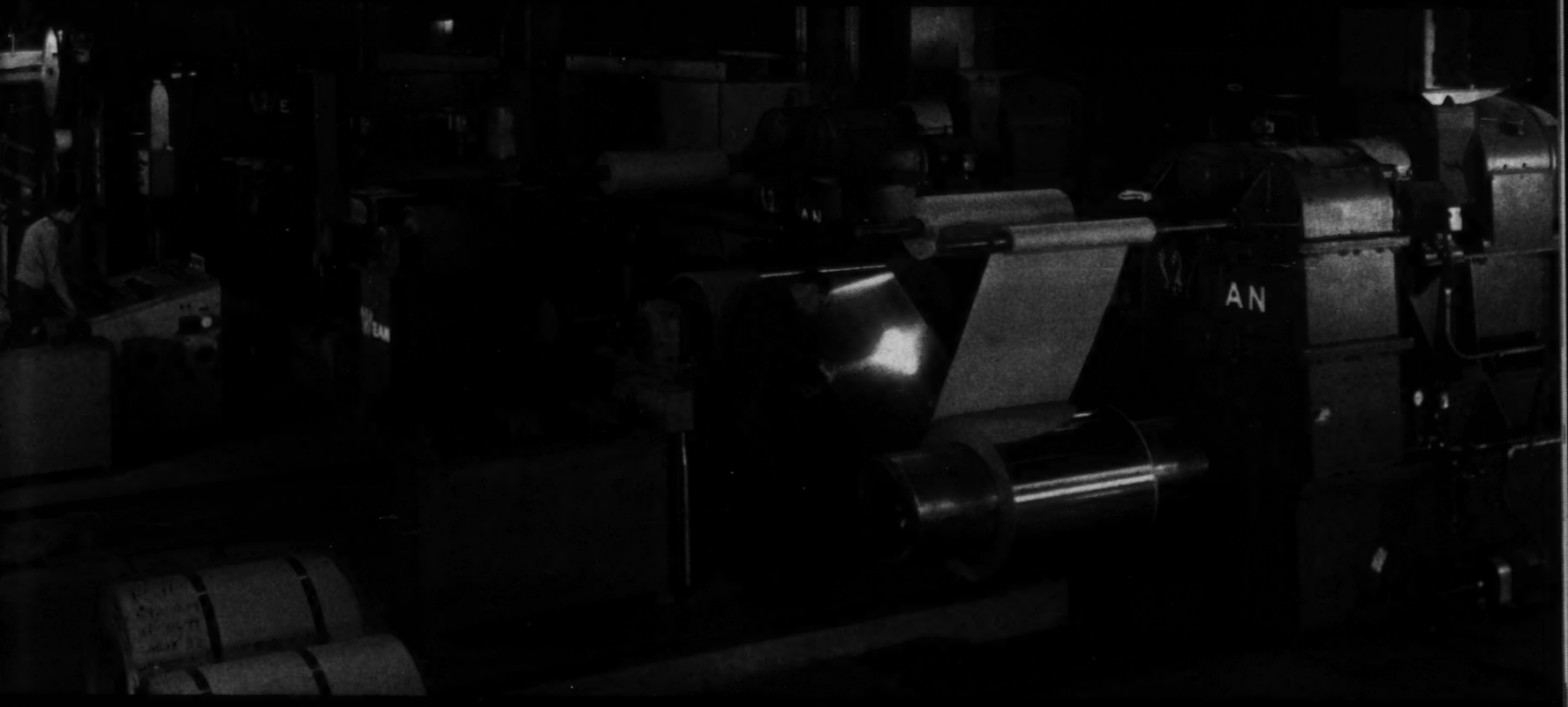
▲ Coil Preparation Line for Incoming Hot Rolled Sheet

▲ The 54" Temper Mill

▼ Hot Anneal Furnace—Entry End

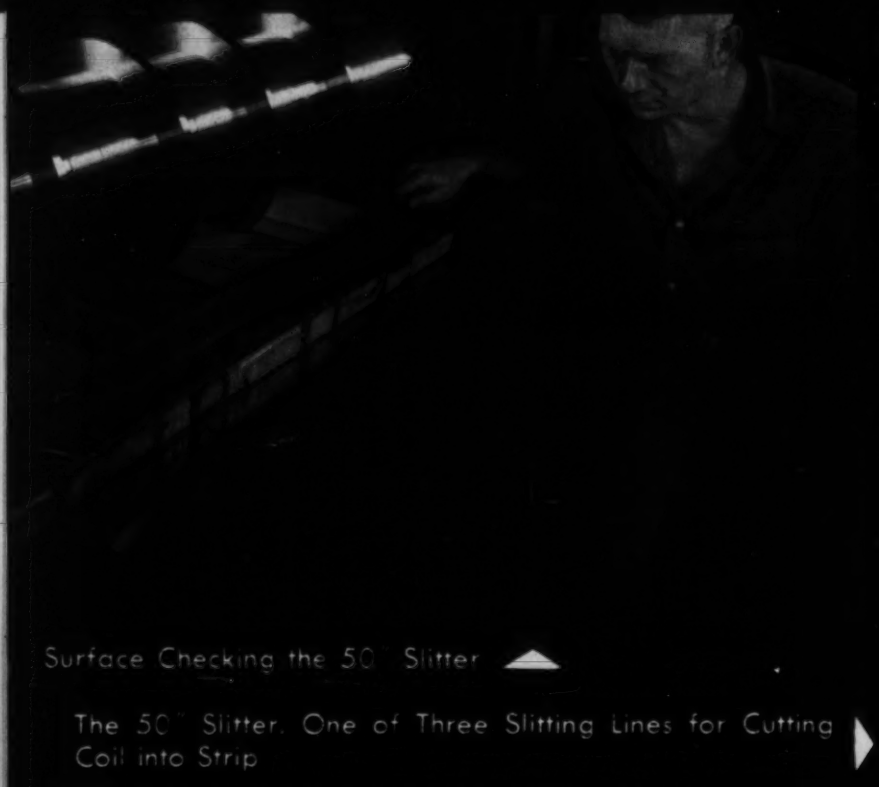
▲ The Sendzimir Mill

Interior View of the Intricate Mechanism of the Sendzimir Mill ▶

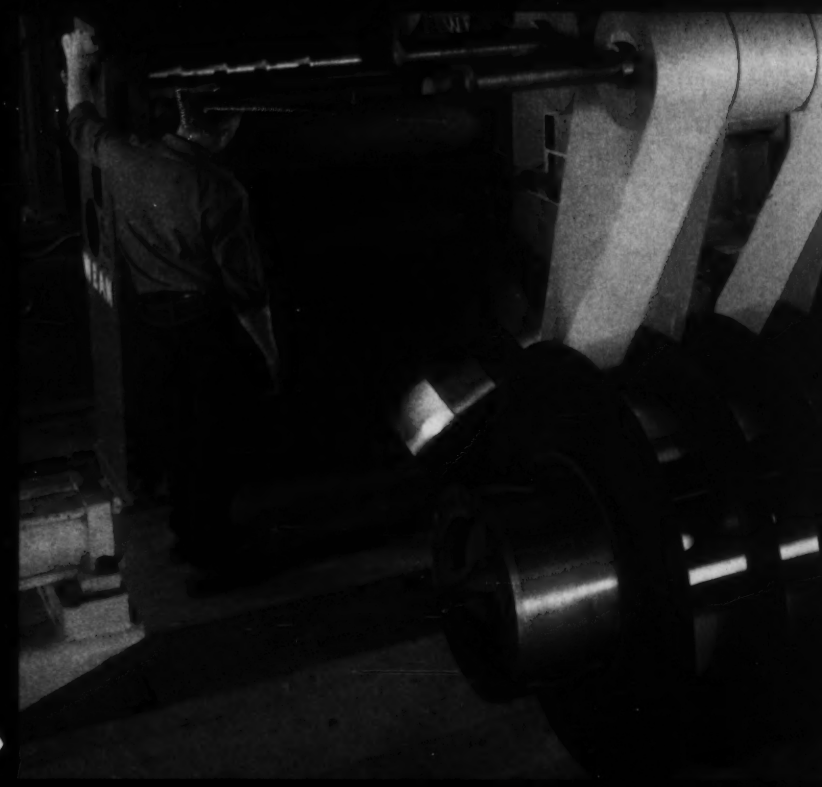


Scouring and Scrubbing Line ▼

▲ Cold Roll Anneal and Pickle Line—Discharge End



Surface Checking the 50" Slitter



The 50" Slitter. One of Three Slitting Lines for Cutting Coil into Strip

One of the two Shear-to-Length Lines for Cutting Coils into Specified Sheet Lengths

Write for your copy of the J & L Stainless Steel Sheet and Strip Manual today

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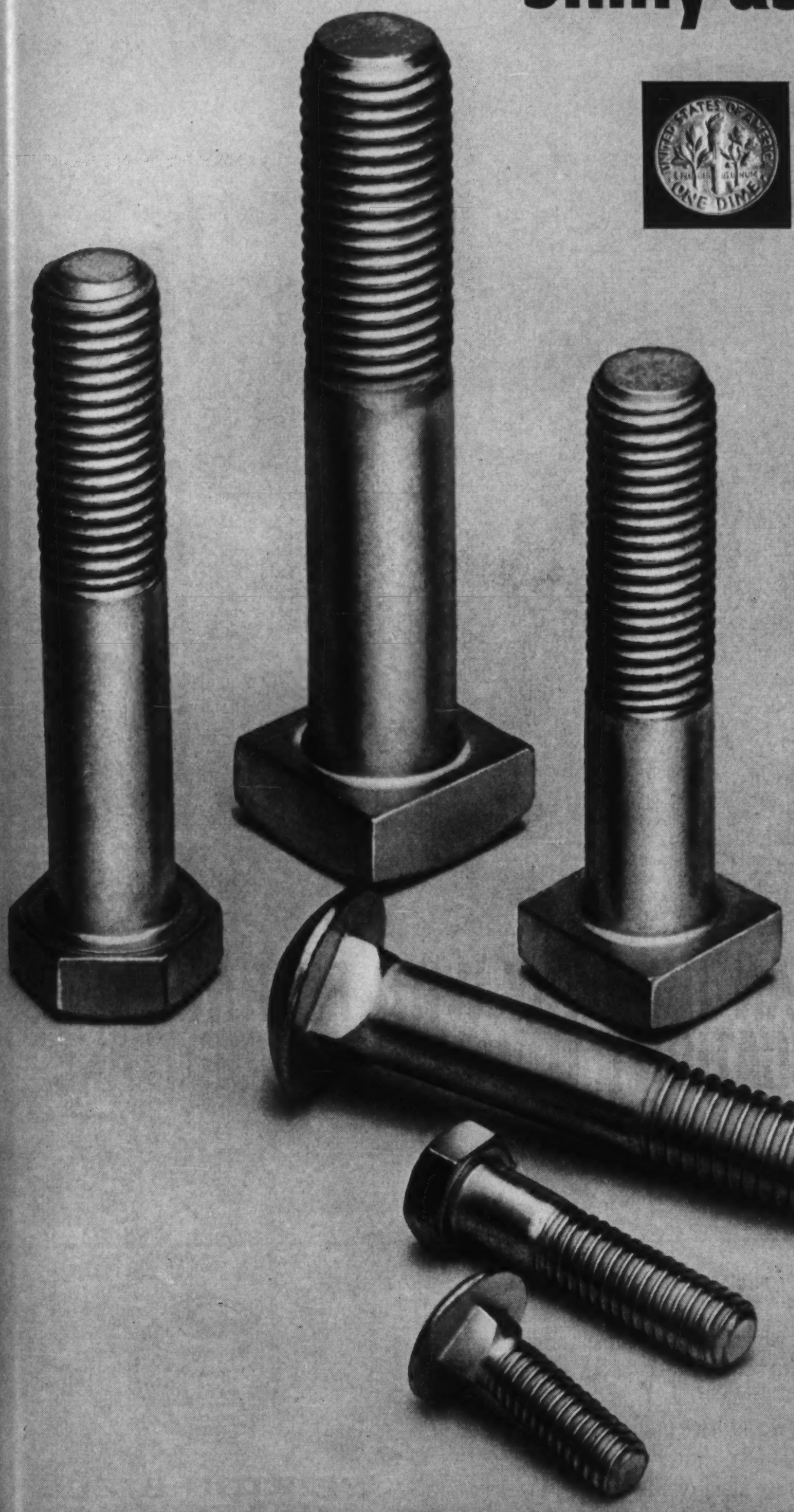
Shiny as a new dime



When you need steel fasteners that look their very best, order Bethlehem electroplated fasteners.

Bethlehem bright-zinc-plated fasteners enhance the appearance of bolting applications because they have a smooth finish that is shiny and rich-looking. They meet ASTM Specifications A-164-55 RS, LS, and GS, and can be produced with definite classes of thread fit in all sizes up to a length of about 30 in.

Bethlehem cadmium-plated fasteners are also available, made to ASTM Specifications A 165-TS, OS, and NS. Type TS is the most popular thickness.

Where conditions call for increased resistance to certain types of corrosion, we have the facilities to passivate electroplated fasteners by means of a dichromate dip, or by using surface conversion coatings, such as iridite and cronak.

Regardless of the styles or quantities you need, just say the word, and we'll have a representative call to tell you more about electroplated fasteners.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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"...AND WEIRKOTE® CAN DO AWAY WITH PLATING OR DIPPING AFTER FABRICATION! IT WON'T PEEL OR FLAKE."

Q. A zinc-coated steel that won't peel or flake? That could save us a lot of money every month. Just what makes this Weirkote so special?

A. It's made by the continuous process, you know, which integrates zinc and steel so that the toughest fabrication won't break down the bond. You can work Weirkote to the very limits of the steel itself.

Q. Of course, that means the most complicated parts would have protection against rust. I like what I'm hearing. Is there more?

A. Yes . . . now Weirkote is treated to inhibit wet storage stain (white oxide). To make a long story short, I'd say this: With Weirkote, you can turn out a better product at lower cost. And you can free a lot of the capital, floor space and time you have tied up in plating operations.

Send for free booklet that details the time- and cost-saving advantages of skin-tight zinc-coated Weirkote. Weirton Steel Company, Dept. E-7, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

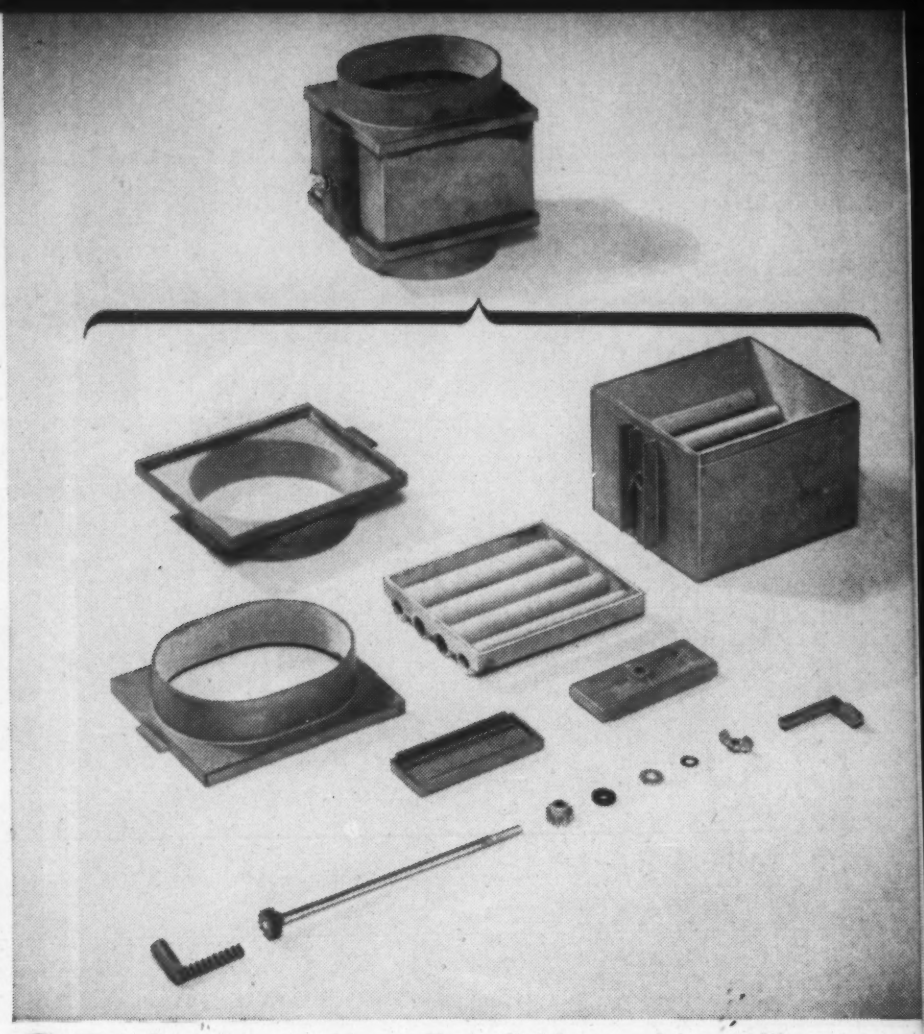
WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 440

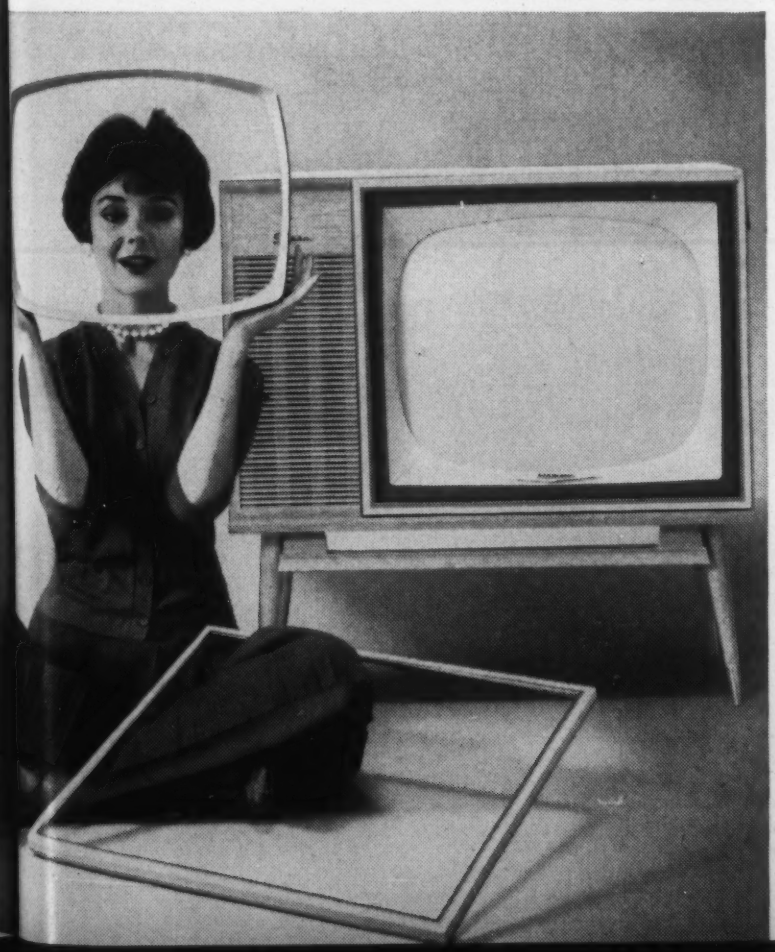
D-J casts, finish machines, plates and assembles door hardware for a Mid-West merchandiser. Eleven zinc rts are die cast . . . then tapped, reamed, faced and plated. her parts are drawn and stamped as needed. Springs, lock shers, screws, locks and keys are purchased. Finally, D-J sembles and packages the units.



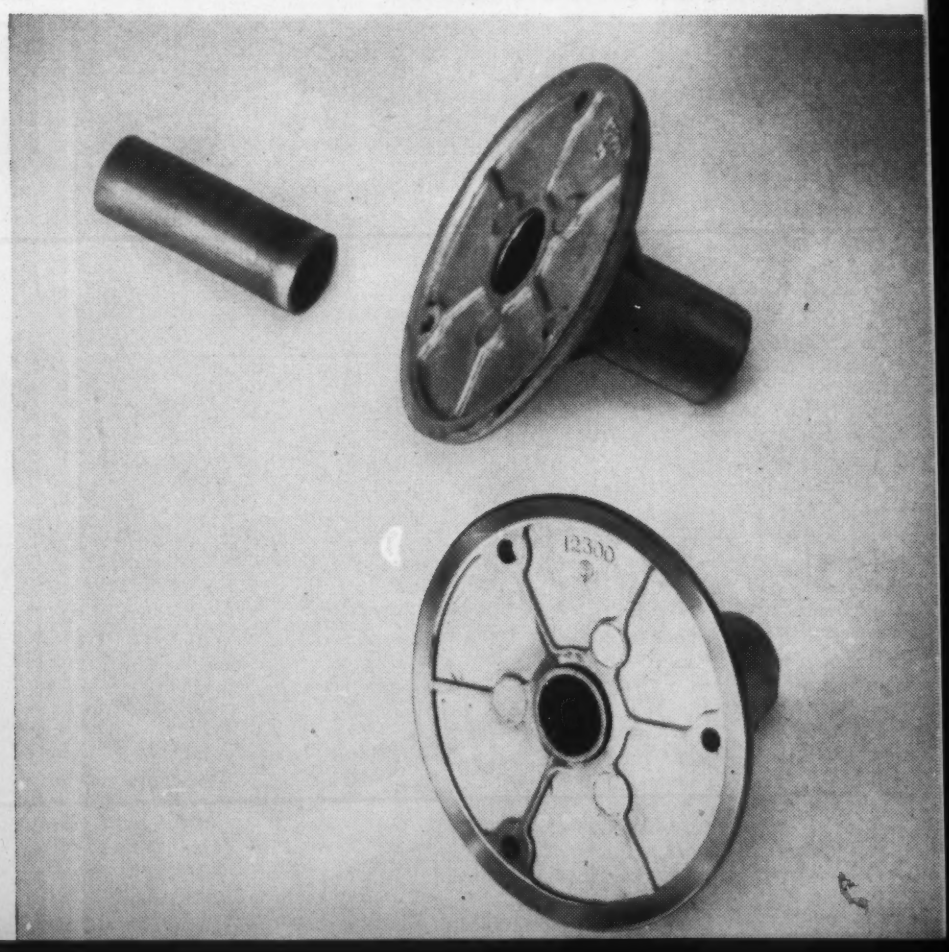
D-J die casts, machines, flock finishes and assembles damper for York Corporation. Unit is a complex high precision assembly of ten die cast parts including racks, pinions, and pistons. D-J flocks interior parts before assembly, seals seams to air-tightness under pressure. Exterior surfaces are carefully alodined.

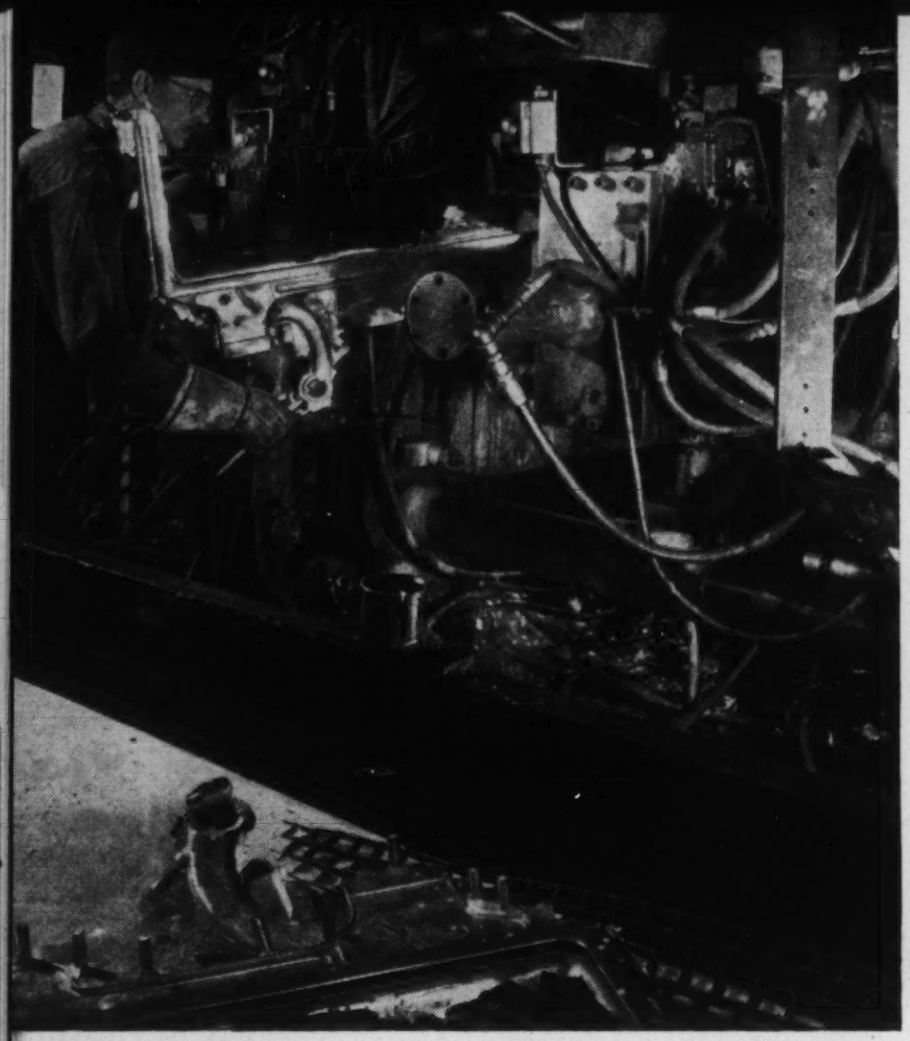
3 pages of <u>proof</u> Doehler-Jarvis can do more for you than die cast parts...

D-J casts, profile shapes, taps and electro-statically paints TV set parts for Radio Corporation of America. Ready- r-assembly die castings are by far the lowest-cost way to pro- ce lightweight metal bezels and glass retainers for RCA ctor TV sets. Their dimensional stability speeds assembly.



D-J casts, machines, and assembles turntable hubs for well-known phonograph manufacturer. Hubs are trimmed, turned, slotted, reamed and fitted with bearings. The bearings are then chamfered and sized. Tolerances of 0.001 inch or less are maintained throughout all these operations.



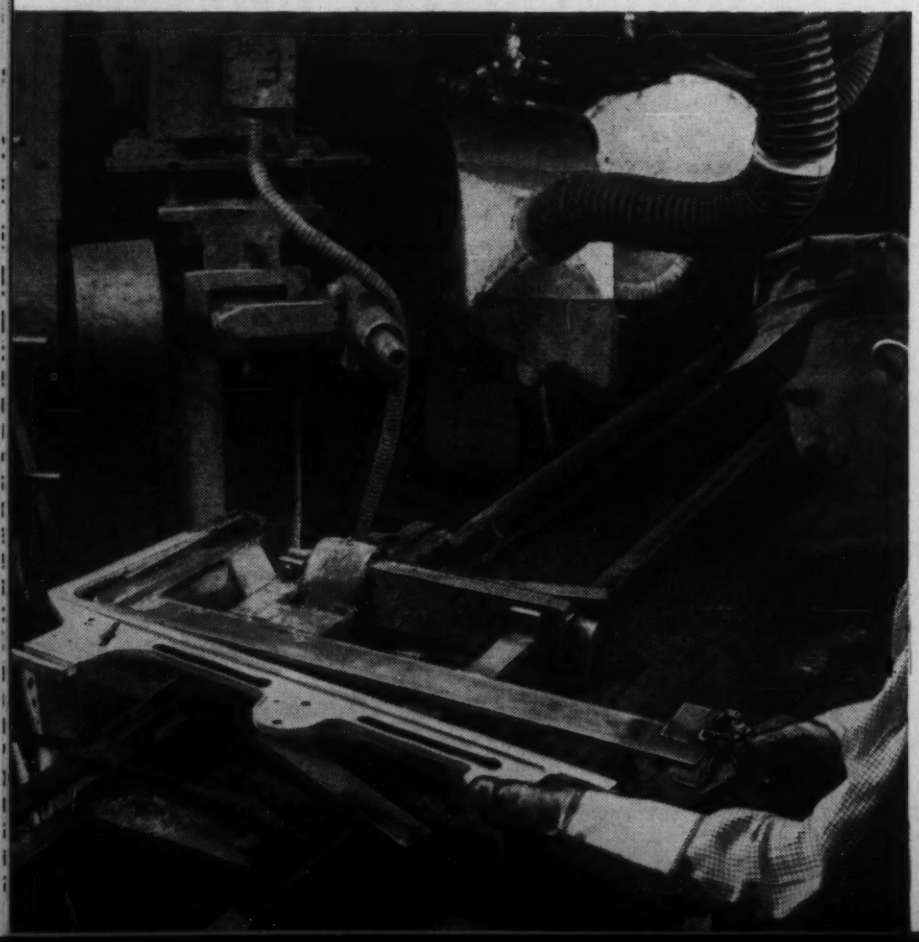


1 **Operator removes die cast zinc main channel** for Lincoln or Continental window assembly from large 48" casting machine. Part is quenched in cooling solution then conveyed to trimming. D-J is now researching production techniques on giant 72" machine, world's largest.

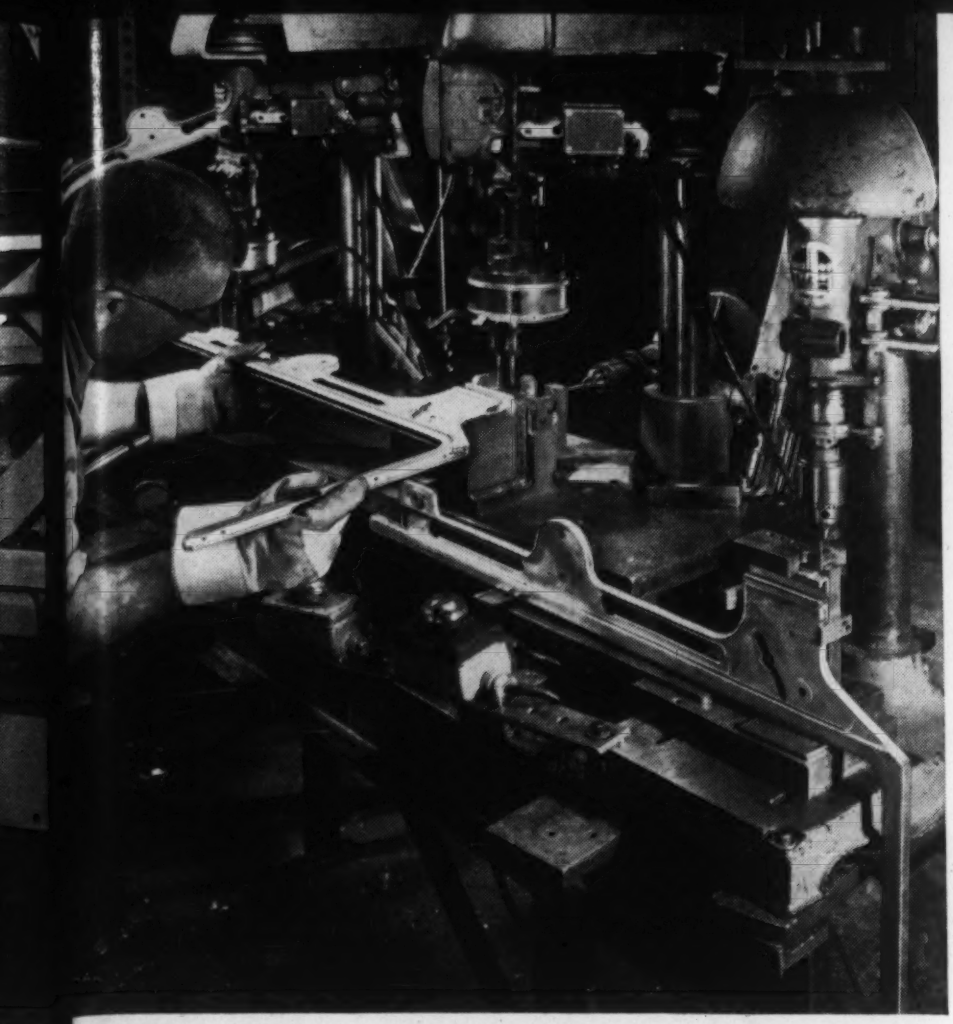
2 **Ingenious double-acting trimmer removes gate,** trims flash, finishes slots, taps 3 holes. Notice jig at right miters corner of frame. Scrap metal is collected, re-melted, re-refined and re-used. Minimum metal consumption is a big advantage of die casting.

..D-J makes, machines, plates, puts togethe

4 **Buffing, too, is set up for maximum economy.** Part is snap-clamped to device that positions it automatically for buffing wheels. When leaving fast-moving buffing lines, parts are racked and processed by conveyor through degreasing into plating without further handling.



5 **"Christmas trees" carry channels through plating.** Part is given optimum copper, nickel, chrome thicknesses using an automatic "plate-on-plate-off" current sequence that develops unusually high quality long-lasting finish desired for this premium car.



3 **Ganged machines complete drilling, tapping, reaming.** Behind operator you can see a universal work toting device. Removable pins support work and present it to operator prepositioned for speediest handling. (For another view of device, see following picture.)

a window assembly for the Lincoln Continental

Not everyone knows that Doehler-Jarvis does extensive machining, finishing and sub-assembly work as well as die casting.

But it's true. Every Doehler-Jarvis Plant (8 in the U. S. and Barber Die Casting in Canada) mass produces sub-assemblies, as well as die casting and finishing basic parts. And you can rest assured, costs undercut those that customers might achieve in their own plants.

Costs are bound to be low. Doehler-Jarvis has in abundance versatile machining, metal forming and joining equipment plus finishing facilities that are unique. Experienced design, purchasing and production personnel, too. Everything needed to set up economical, continuous production, assembly, and packaging lines.

6 **Window is glazed and finish assembled in special jig.** Here die cast channel, glass and other parts (some made, some purchased by D-J) are put together and weather sealed. Packaged part is shipped both to the Lincoln and Continental plants and to distributor warehouses.

There are other savings, too . . . savings in *your* plant. Less tooling, for example. And you receive a responsibly inspected, fully functional sub-assembly ready for immediate use. Many D-J customers take delivery only on sub-assemblies needed for basic production. Spare-part production goes directly to customer's distributors.

Makes sense, doesn't it? Especially when you see, as in these three pages of pictures, how D-J handles typical production work.

Maybe you could push your costs down this way, too. Care to talk it over?

Doehler-Jarvis

DIVISION OF NATIONAL LEAD COMPANY

General Offices: Toledo 1, Ohio

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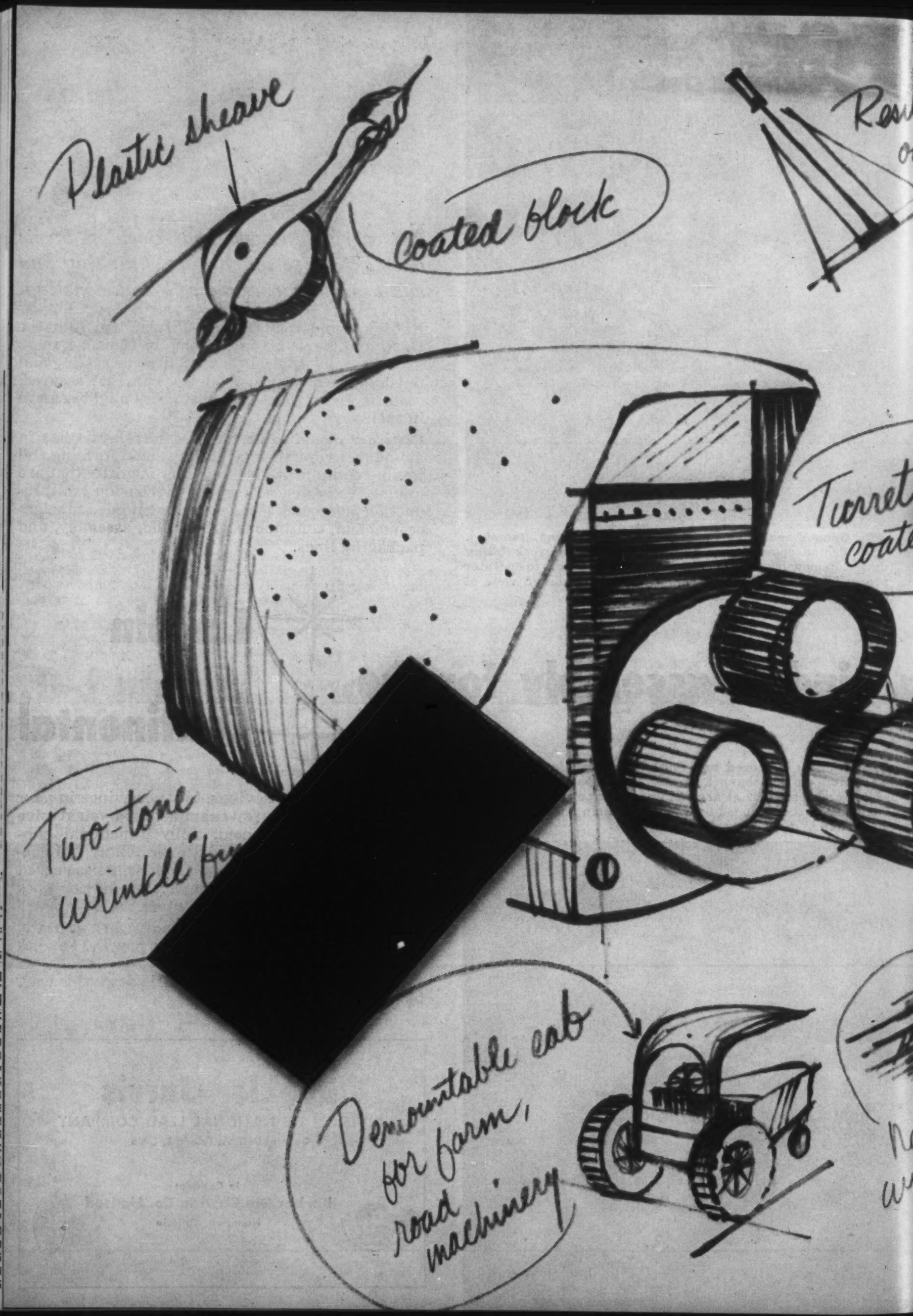
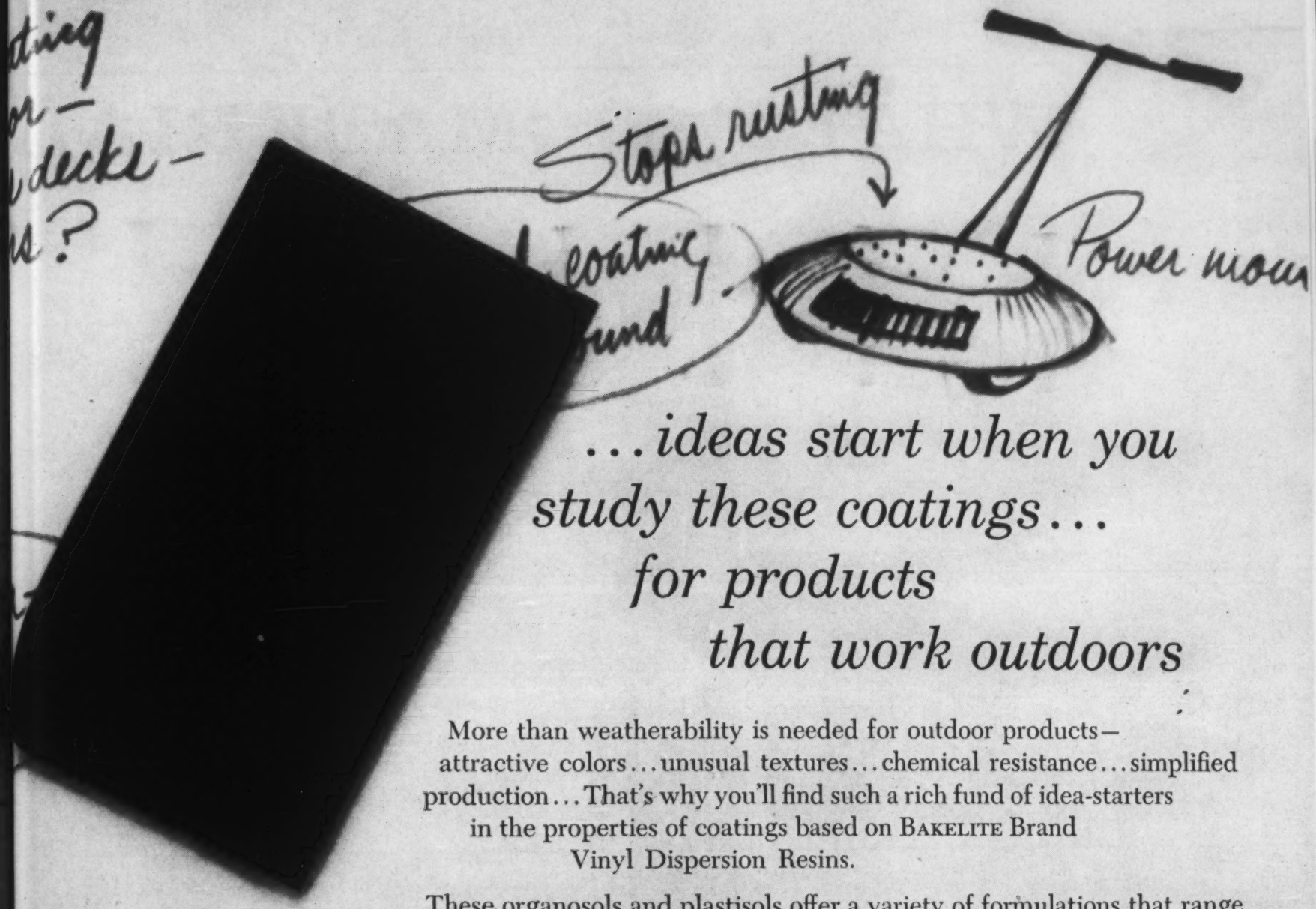
Barber Die Casting Co. Limited

Hamilton, Ontario


Plastic sheave
coated block
Turret
coate
Two-tone
wrinkle
Demountable cab
for farm,
road
machinery



...ideas start when you study these coatings... for products that work outdoors

More than weatherability is needed for outdoor products—attractive colors...unusual textures...chemical resistance...simplified production...That's why you'll find such a rich fund of idea-starters in the properties of coatings based on BAKELITE Brand Vinyl Dispersion Resins.

These organosols and plastisols offer a variety of formulations that range from glossy to textured, from hard to resilient. They can open up entirely new fields for coatings.

One type, for example, is applied in a quarter-inch thickness for cushioning metal and even providing electrical insulation. Another rugged variety outlasted ordinary coatings tenfold in abrasion tests. The chemical resistance of still another has led to its use in lining chemical drums. Metal coated with these materials can be post-formed – they won't crack, chip, or lose adhesion. Some types can be molded.

In fact, they can be used for roller-coating, spraying, knife coating, dip coating, slush molding, rotational molding, casting, and extrusion . . .

Learn how coatings based on BAKELITE Brand Vinyl Dispersion Resins can improve your product designs. Write for the names of coatings formulators who work with them, or for technical information on specific uses. Address Dept. LV46L, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

It pays to design with coatings based on **BAKELITE** BRAND **PLASTICS**

UNION CARBIDE

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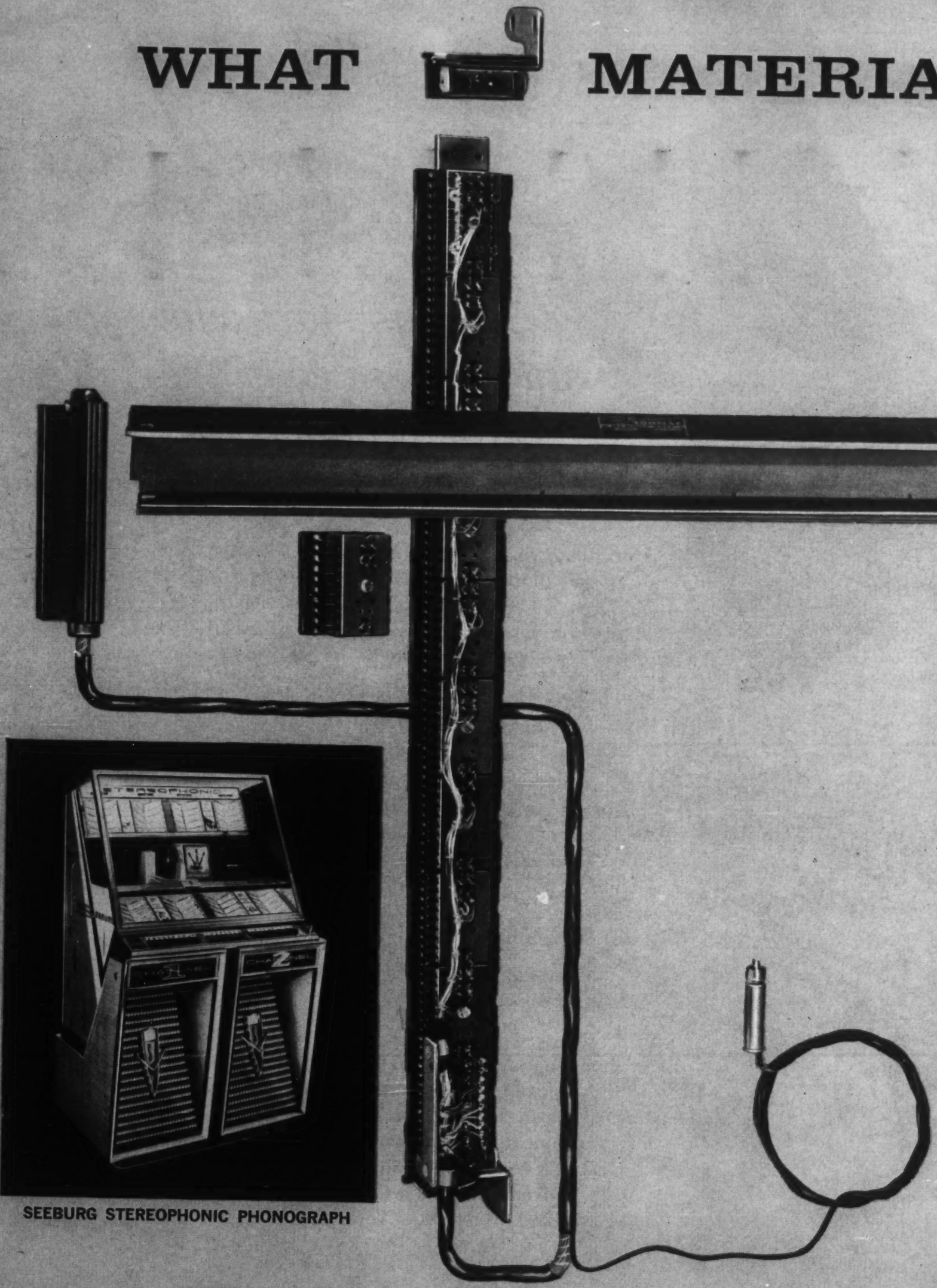
WHAT MATERIAL



SEEBURG STEREOPHONIC PHONOGRAPH

IS ALWAYS NEW?

BAKELITE
BRAND
PLASTICS

...offering new freedom in design...and cost... and functional advantages!

It continually appears in *new* compounds and forms to meet new specifications.

It encourages the creative talents of design engineers, architects and interior and industrial designers.

You *know* the answer—BAKELITE Brand Plastics.

And BAKELITE Brand Plastics almost invariably offer cost, production, and functional advantages *as a plus!*

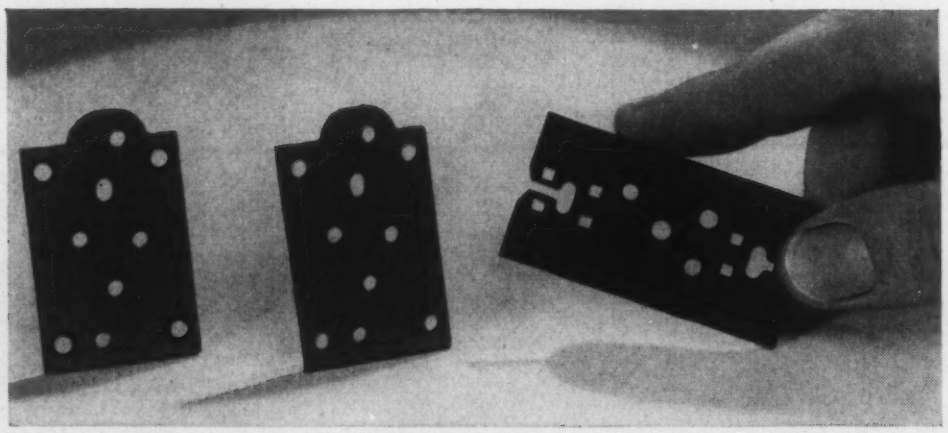
An example of the improvements in design made possible by BAKELITE Brand Plastics is shown at left. It is the first electronic brain, or memory unit, for music machines and jukeboxes. This assembly replaces the old electro-mechanical relay system of record selection and programming, which had moving parts that could wear out or fail.

Whatever your design area, no matter how unusual the qualities you require for forming, strength, rigidity, flexibility, insulation, corrosion resistance—explore the proven advantages of BAKELITE Brand Plastics and Resins. The material that's new all the time!

Technical representatives with years of training and field experience are available to discuss your special design problems. Write Dept. **LV-52D.**

BAKELITE Brand Polystyrene was chosen to encase this domestic food waste disposer...another example of a plastic meeting **exact** specifications. Ease of molding was required for the graceful design, along with chemical inertness, resistance to heat, attractive color and luster, durability and high impact strength. Molded of BAKELITE Brand TMDB-5161 for Waste King Corp., Los Angeles, by Modern Plastic Co., Los Angeles, and Industrial Molding Corp., Culver City, Calif.

* * *



BEARING PLATES and TERMINAL BOARDS of "BAKELITE" Brand Phenolic are important components in the new automatic memory unit shown on the left-hand page. Using miniature toroid cores made of powdered ferrite material, operation is similar to that of giant electronic brains. BAKELITE Brand Phenolic was chosen for its excellent electrical insulation properties, high temperature resistance, impact strength, and dimensional stability. Developed by The Seeburg Corporation, Chicago, with parts molded by Mayfair Molded Products, Schiller Park, Ill., and stampings by Fibre Fabricators and Spaulding Fibre Company, both of Chicago.

UNION CARBIDE PLASTICS COMPANY
Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.
In Canada: Carbide Chemicals Company, Division of Union Carbide Canada Limited, Toronto 7
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BAKELITE COMPANY
has a new name...
UNION CARBIDE PLASTICS COMPANY
DIVISION OF UNION CARBIDE CORPORATION

USS Amerstrip..

Shown here is the difficult deep-drawing operation for the Amerock window sash lifts. The sash lifts are being blanked, drawn, pierced and trimmed on a 60-ton Rockforn Punch Press at the rate of 1100 per hour. USS Amerstrip has performed so successfully on this operation that it is now used exclusively for this window lift.

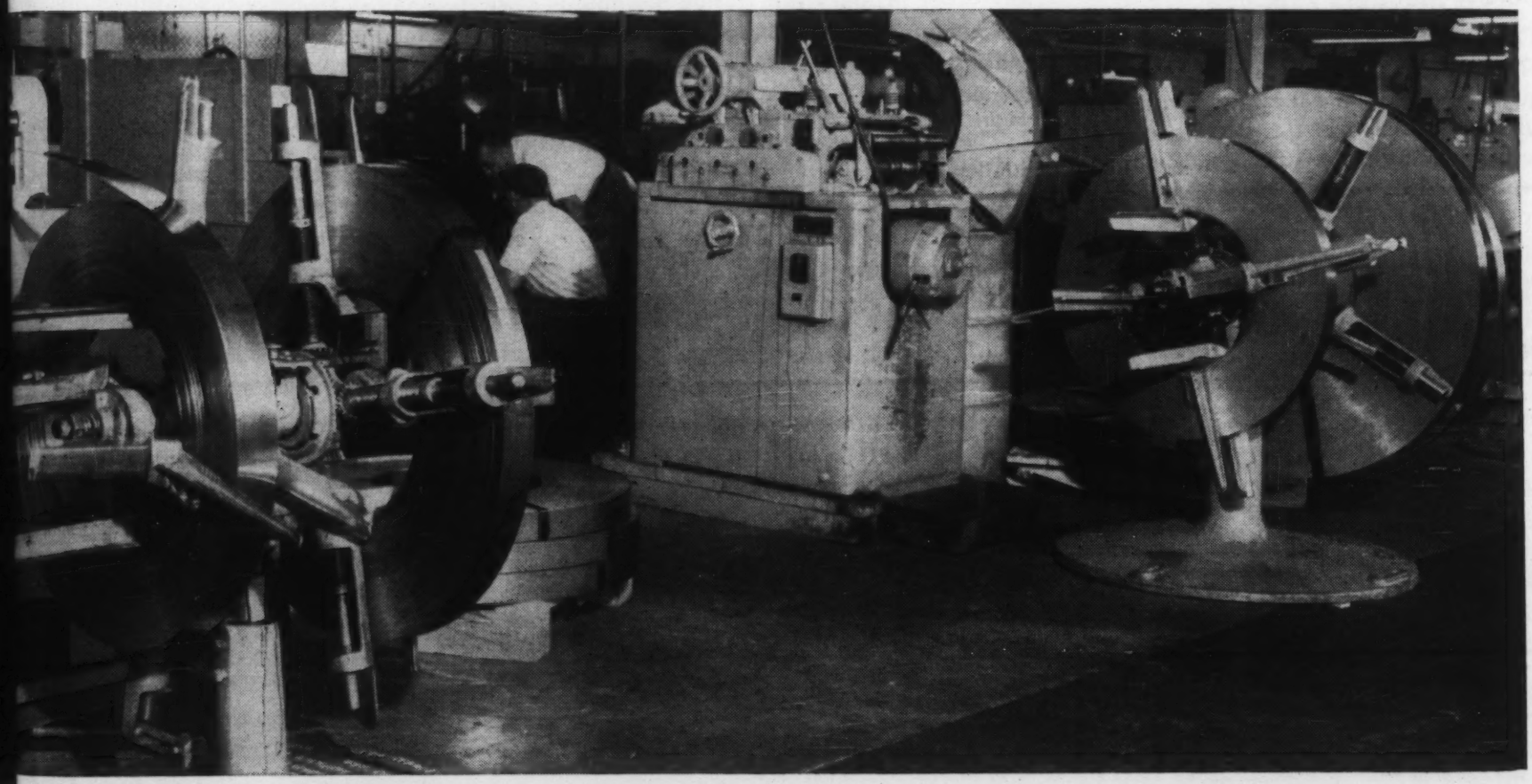
. solves difficult double-draw problem
. maintains finish for plating

When the Amerock Corporation of Rockford, Illinois, decided to make their unusual sash lift from strip steel instead of another metal, they ran into difficulties. The several different types of strip steel they tried failed to stand up under the severe forming operation. American Steel & Wire Division was then consulted, and their recommendation for a 4 Temper, #2 Finish, Deep-Drawing USS Amerstrip proved ultimately to not only fulfill the deep drawing requirements, but permitted satisfactory plating.

Joe Ellis, foreman of Amerock Blanking Department, said, "AS&W did an excellent job in developing a strip steel which would do this difficult double draw, yet maintain its finish for plating. We have had more trouble from other steels doing simpler jobs."

In the past 28 years the Amerock Corporation has grown to be the world's largest manufacturer of cabinet hardware. In addition to the window lift, many other items in their complete line of functional hardware are fabricated from USS Cold Rolled Amerstrip, including drawer pulls, hinges, knobs and cabinet hardware.

American Steel & Wire. General Offices: Rockefeller Bldg., Cleveland 13, Ohio. *USS and Amerstrip are trademarks*



Coils of USS Amerstrip are being fed into the Lytell Straightening Machine. When the smaller coil is gone, the holder is pivoted to permit the remaining coil of Amerstrip to be fed into the machine.

American Steel & Wire Division of USS United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

For more information, turn to Reader Service Card, circle No. 465

DESIGNING WITH ALUMINUM

NO. 29

This is one of a series of information sheets that discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

DESIGNING WITH ALUMINUM SCREW MACHINE PRODUCTS

RECENT INNOVATIONS in screw machine equipment have made possible great strides in the accuracy, versatility and output rates of both single and multiple spindle machines. These advancements, such as spindle-stopping attachments, increased spindle speeds and numerous secondary-operation accessories, along with the superior working qualities of improved aluminum alloys, have created new opportunities for the designer of precision, high-volume production parts.

Advantages of the Screw Machine Process

The screw machine process serves two primary design considerations: high quality and low production cost. Thus, whenever design of the parts permits, screw machining is usually chosen in preference to other fabricating methods.

High quality of product is, in part, the result of high quality starting materials. The rod, bar and wire used in screw machine work is wrought during the forming process, thus acquiring good density, low porosity and fine grain structure. These properties are conducive to excellent machinability, faithful detail and fine surface finish.

Materials having these properties, when worked in a process of inherently high accuracy and close control, produce parts of dependable dimensions and great uniformity. Accurate concentricity and mating-part fits are attained, with closer tolerances possible than in any other primary fabricating method. For example, Class 3 threads, and other features of similar fineness, may be turned without undue difficulty.

The properties contributing to high quality also contribute to low production cost. Fewer secondary operations are necessary, because of the fine as-machined surface finishes, the intricacy of detail and the dimensional accuracy possible in the basic screw machine process. Rejection rates are low, and subsequent automatic handling processes are facilitated by the uniformity of the parts.

Reduced unit costs also stem from the wide range of available high speed equipment and mill-standard raw materials, the relative simplicity of machining set-up and the faster delivery of finished parts. Expensive dies and fixtures are not required. And because stock cutting tools generally may be used, tooling and maintenance costs are minimized. In-process modification of parts is relatively quick and easy.

Added Advantages with Aluminum

The designer will find these native features of the screw machine process even more valuable when the physical and mechanical advantages of aluminum are considered.

Fig. 1

TYPICAL PROPERTIES OF ALUMINUM SCREW MACHINE ALLOYS COMPARED WITH STEEL AND FREE-CUTTING BRASS

	Tensile Strength (psi)	Yield Strength (psi)	Shear Strength (psi)	Elongation (% in 2 In.)	Hardness (Brinell)	Modulus of Elasticity (psi)	Density (lb./cu. in.)	Electrical* Resistivity	Thermal† Conductivity	Thermal Expansion (68 to 580 F.)
B1113 Steel (Cold Drawn)	85,000	75,000	—	14	170	29.0×10^6	.283	20.0	360	12.8×10^6
C1018 Steel (Cold Drawn)	82,000	70,000	—	20	163	"	"	"	"	"
B1112 Steel (Cold Drawn)	82,500	71,000	—	15	170	30.0×10^6	"	"	"	"
#271 Brass (Free Cutting)	58,000	45,000	34,000	25	143	14.0×10^6	.307	6.6	800	20.5×10^6
ALUMINUM ALLOYS										
2011-T3	55,000	43,000	32,000	15	95	10.2×10^6	.102	4.8	990	22.9×10^6
2011-T8	59,000	45,000	35,000	12	100	10.3×10^6	.102	4.8	990	
2014-T4	62,000	42,000	38,000	20	105	10.6×10^6	.101	5.7	840	23.3×10^6
2017-T4	62,000	40,000	38,000	22	105	10.5×10^6	.101	5.7	840	23.5×10^6
2024-T4	68,000	47,000	41,000	19	120	10.6×10^6	.100	5.7	840	23.2×10^6
6061-0	18,000	8,000	12,000	30	30	10.0×10^6	.098	3.8	1190	23.5×10^6
6061-T4	33,000	21,000	24,000	25	65	10.0×10^6	.098	4.3	1170	
6061-T6	45,000	40,000	30,000	17	95	10.0×10^6	.098	4.3	1170	
7075-T6	83,000	73,000	48,000	11	150	10.4×10^6	.101	5.7	840	23.6×10^6

*In microhms/cm. at 68 F. †In B.T.U. per inch per square foot per hour.

While almost all aluminum alloys are well adapted to machining, a number of them are especially designed for turn-cutting operations. The wide range of these alloys permits matching the characteristics of the alloy to the working requirements of the part. Some aluminum alloys provide strength properties approaching those of cold-drawn mild steel. Others have machining qualities equal to free-cutting brass. All have good corrosion resistance under proper conditions of use.

Alloy 2011, for example, the most popular aluminum alloy for screw machined products, is an especially free-machining metal with excellent mechanical properties, accepting heavy feeds at high cutting speeds. This alloy, and some of the other aluminum alloys available for the designer's selection of optimum property combinations, is listed in Fig. 1 along with representative brass and steel materials.

Alloy 2017, which like 2011 is one of the most frequently selected aluminum alloys for screw machine work, has somewhat higher ductility than 2011, while retaining good machining qualities.

Strongest of these copper-bearing aluminum alloys is 2024, which can be readily roll-threaded, spot welded and finished to fine surface qualities. It is widely used for durable fittings and fasteners.

The 6061 and 7075 alloys listed in Fig. 1 illustrate the versatility of aluminum for screw machine product applications. Note that 6061, for example, increases five-fold in yield strength from its annealed condition to its T6 temper stage, which is attained simply by heat treating. This 6061 material is readily welded by all methods, may be torch or furnace brazed, and has good resistance to corrosive attack as well as excellent machinability.

Alloy 7075 offers the strength qualities of cold-drawn steel *at one-third of the weight per volume* in an easily machined, spot weldable material.

More Helpful Design Properties

In addition to their qualities of superior machinability and high strength-to-weight ratio, these aluminum alloys offer many other properties helpful to the screw machine product designer.

For electrical usages, aluminum alloys offer conductivity, in proportion to weight, ranging up to double that of electrolytic copper. Similarly, thermal conductivity is higher than in free-cutting brass and three or four times greater than in ferrous metals. This quality affords quick, even distribution of heat, where heat is desired, while providing rapid dispersion of undesirable heat. Thus, aluminum terminals, fittings and other parts designed for screw machine fabrication are of great value in electrical equipment, appliances and other high-volume production items.

Another unique property of aluminum, valuable to many modern designers, is its retention of structural strength at low temperature levels. Aluminum alloys actually increase in tensile strength and elongation, without embrittlement, as temperatures drop. The increasing demand for precision fittings and accessories in liquid-gas fueled missiles, for example, gives great significance to this unusual feature of aluminum for screw machine parts.

Still another valuable design property of aluminum is superior resilience under stress, especially in the stronger alloys, due to low modulus of elasticity. In a component subject to normal operating loadings, not involving excessive impulsive shocks or fatigue effects, the ability, "U," of a metal to absorb energy from tensile or compressive strains may be expressed as:

$$U = V\frac{S^2}{2E}$$

where stress S, in psi, does not exceed yield strength; V is the volume of metal under this stress; E is elastic modulus.

The relative capacity of aluminum to absorb energy may then be observed, for equal volumes and equal elastic strengths, as the simple ratios:

$$\frac{U\ \text{aluminum}}{U\ \text{brass}} = 1.36, \text{ and } \frac{U\ \text{aluminum}}{U\ \text{steel}} = 2.91$$

For equal elastic strengths and equal weights:

$$\frac{U\ \text{aluminum}}{U\ \text{brass}} = 4.1, \text{ and } \frac{U\ \text{aluminum}}{U\ \text{steel}} = 8.1$$

(Equations derived from values in table below—taken from ASM Metals Handbook.)

Metal	E (psi)	Density lbs./cu. in.
Aluminum (2011)	10.3×10^6	.102
Free Cutting Brass	14×10^6	.307
Steel (B1112)	30×10^6	.283

Variety of Finishes Applicable

Among further advantages of aluminum screw machine products is the great variety of mechanical, chemical and electro-chemical finishes applicable to these alloys. While aluminum screw machining alloys have attractive natural appearance, artificially induced finishes may be preferred or required for many applications.

Decorative effects may be obtained by permanent color anodizing or by applied coatings. Other finishes are used to reduce non-lubricated friction between moving surfaces in contact, to improve resistance against abrasion and corrosion, to provide better adherence of paints or adhesive materials, and for many other reasons. Some of these available finishing processes are described in Fig. 2 on following page.

Some means of corrosion protection may be required when aluminum screw machine products are used in contact with dissimilar metals in a corrosive environment. Various means may be used to provide this protection.

Aluminum Offers Cost Advantages

Further help in solving the designer's problems in production economy is offered by the behavior of aluminum in shop handling and machining. The mill-standard starting materials are available, in broad size ranges, from distributor stocks throughout the country. Providing three times as much volume per pound as heavier common commercial metals, aluminum use reduces freight and shop handling costs for both raw materials and finished products. Natural corrosion resistance reduces or eliminates need for special protective attention under storage.

In the machining process, aluminum materials offer more rapid dissipation of heat, long tool life and greater stability of as-machined finish. The lightweight, finely-divided chips are easy to remove from production parts and machinery. Thus, the advantages of designing with aluminum alloys are found in all phases of cost, convenience, fabrication and function.

What the Designer Conceives... Aluminum Achieves

To help designers make full use of up-to-date developments, the following

Fig. 2

SOME AVAILABLE FINISHES FOR ALUMINUM SCREW MACHINE PRODUCTS

Type of Finish	Name of Finish	Principle Purpose of Finish
Mechanical	Grinding	To remove surface imperfections.
	Polishing, buffing and coloring	To remove surface imperfections and to achieve decorative finish.
	Scratch brushing	To obtain a coarse- or smooth-lined texture.
	Satin finish	To obtain a soft, smooth sheen.
	Burnishing	To impart fine finish to a large number of small parts.
	Sand blasting	To produce a uniform matte surface.
Chemical	Caustic Etch	Decorative "frosted" finish.
	Crystalline chromate	Paint base.
	Chromate-phosphate-fluoride	Paint base.
	Phosphoric acid	Paint base.
	Chemical polishing	Bright finish or base for anodizing.
	Zincate	Base for electroplating.
Electrolytic Oxide	Sulfuric acid anodize	Hard, corrosion-resistant oxide film, base for dyed coatings.
	Chromic acid anodize	Hard, corrosion-resistant oxide film.
	*Hard anodizing	Extremely hard, corrosion- and wear-resistant film.
	Electrolytic polish	High light reflectivity.
Electroplating	Chromium plate	Abrasion-resistant and decorative.
	Copper plate	To promote solderability, decrease electrical surface-resistance.
	Silver plate	Decrease surface resistance.
Painting	Paint, lacquer, enamel	Decorative, corrosion resistant.
	*Porcelain enamel	Hard, decorative, corrosion-resistant coatings.

*For use only with 6061 aluminum alloy.

checklists summarize the advantages of modern screw machine production and the advantages of aluminum:

12 Advantages of Screw Machine Production

1. Starting material is a wrought product which gives high properties in the finished part.
2. Very fine threads possible—as well as accurate threading.
3. Excellent finishing possibilities—anodizing, etching, buffing, etc. As-machined finish gives very fine surface.
4. Closer tolerances and more intricate parts possible than with other methods. Mating parts match better.
5. Excellent concentricity is guaranteed.
6. Fewer rejects for porosity when compared to a cast part.
7. Lower costs for production tooling, dies, set-up; faster delivery of finished parts possible due to fast availability of tooling, speed of set-up.
8. Modification of parts in production easier and less costly.
9. Wide range of equipment and facilities available throughout the country.
10. Fewer secondary operations necessary; possible to avoid secondary finishing by using the as-machined surface.
11. Lower costs for actual production due to high rates of production with available new equipment.
12. Lower costs for finished parts due to competitive pricing among large number of suppliers.

12 Advantages of Aluminum

1. Light weight—moving parts present less resistance to applied force, wear less; chips float out of recesses better for cleaning finished parts. Easier handling of raw material in plant, lower freight costs on finished parts.
2. Non-magnetic.
3. Corrosion resistant—can often eliminate finishing.
4. Non-sparking.
5. Lower raw material cost per part.
6. Greater conductivity—helps dissipate machining heat.
7. Some alloys less susceptible to radiation absorption.
8. More alloys available than some other metals, allowing a particular alloy to be related to a particular part.
9. Less price fluctuation on raw materials.
10. Stock readily available. Size range broad and well stocked at distributors throughout the country.
11. New procedures in producing aluminum screw machine stock now give greater tool life and higher production. New processes such as Electrofilming and Kanigen Coating have overcome old problems as galling and binding.
12. Technical literature for designing purposes readily available.

Engineering advisory services and technical literature on conversions to aluminum in screw machining are available without obligation to interested manufacturers. For further information and professional design assistance, inquire through the Kaiser Aluminum sales office listed in your telephone directory.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois. *Executive Office*, Kaiser Bldg., Oakland 12, Calif.

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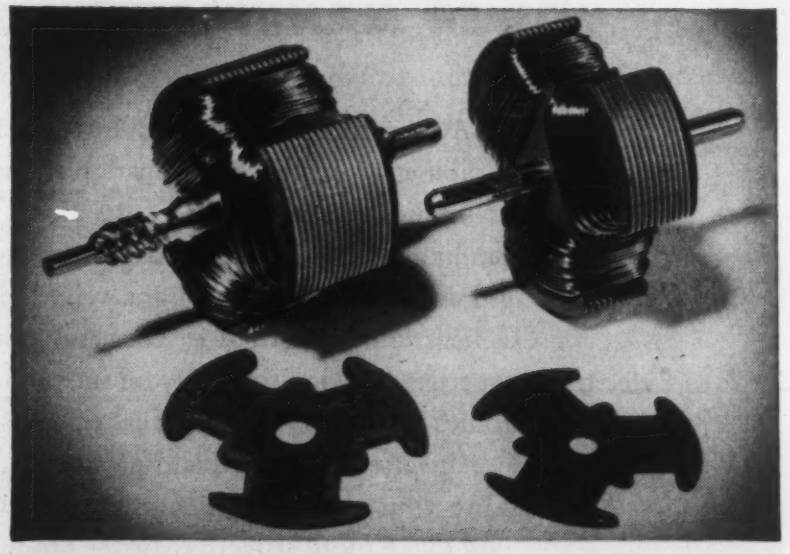
Although primarily applied as insulating materials in electric motors, power supply units, track elements, locomotives and cars—there are many instances where the unique mechanical properties of these materials are effectively put to work. An example is the use of laminated plastic gears (silent gear stock) to transfer power from electric motors.

You, too, may have applications where Taylor vulcanized fibre and laminated plastics will cut costs and improve product reliability. Our application engineers will be glad to discuss them with you. Both our plants—Norristown, Pa., and La Verne, Calif.—are equipped for prompt supply of basic materials or fabricated parts. Write us for details. TAYLOR FIBRE CO., Norristown 45, Pa.



Taylor Vulcanized Fibre Parts Insulate the rotors used to power Lionel model engines. Photos supplied by courtesy of The Lionel Corporation.

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LAMINATED PLASTICS VULCANIZED FIBRE

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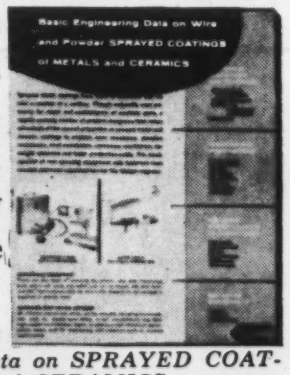
A message to the designers
and producers of industrial equipment

HOW AN ENGINEER CAN BECOME HIS COMPANY'S BEST SALESMAN

Many of the most important users of industrial equipment are users of metallizing. More than 6000 of them today – a list that reads like a Bluebook of American industry. They use this modern process to maintain – *and improve* – the performance of equipment they buy. They have found through long experience that worn areas of machine parts can be made to give double and triple the ordinary service life by metallizing them with materials superior to the base metal. In many cases, new equipment is disassembled and critical parts metallized *before* they are used. These companies do this at very low cost.

You can provide the same advantages on a production basis at a fraction of that cost. Many *manufacturers* of industrial equipment are doing just that because it gives them a competitive sales point that they can use to advantage. One of these days an alert competitor of yours may get the same idea – *and the business.*

It will cost you nothing to find out if metallizing can improve the performance of your product, at low cost; give your company an important sales advantage. A comprehensive Engineering Data Bulletin on metallizing is yours for the asking – or better yet, a conference with an experienced, full-time, trained Metco field engineer in your territory who stands ready to advise users of metallizing as well as prospective users, how this low-cost process can go to work for them. Maybe it can go to work – profitably – for your company. Telephone, wire or write.



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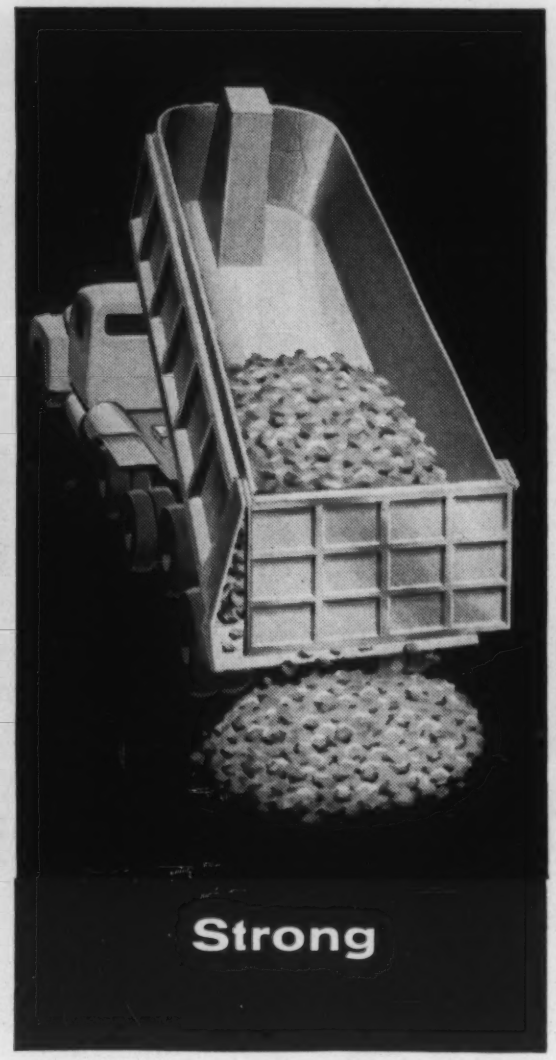
Light Weight



Strong

Good Electrical Conductor

ALUMINUM...*Design-able*

There is probably no one metal with so many favorable characteristics, offering so much to so many applications, as aluminum. It is the *combination* of these characteristics that helps aluminum to improve products, parts, and their production.

As proof of this, consider the staggering growth in usage that this versatile metal has enjoyed just since 1946—over 2 *billion* pounds more aluminum used in 1957 than in 1946. Consider, too, a few of the properties aluminum offers a designer:

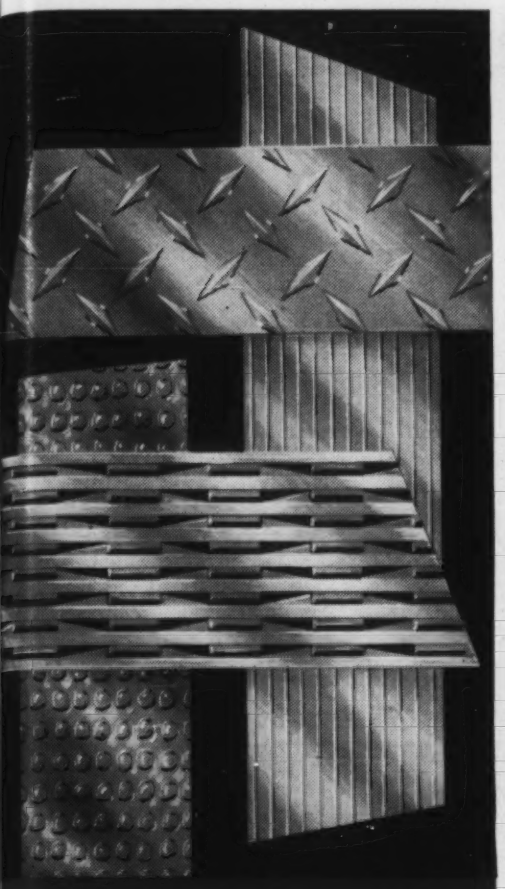
Light Weight—Weighing ⅓ as much as copper, steel and brass, aluminum offers a big advantage for many products where weight is important. Light weight can also mean lower labor costs, lower costs in shipping, handling and installation. And you can get three times as many parts from a pound of aluminum as from a pound of the other metals.

High Strength—Some aluminum alloys are stronger than structural steel. Aluminum alloys are being used in rugged applications like dump truck bodies, building structurals and highway bridges.

Good Electrical Conductor—One of the main reasons you see more and more aluminum in cable, transformer windings, switches, motors, capacitors, and bus duct is its conductivity. One pound of aluminum is equal *electrically* to two pounds of copper. This conductivity, plus its light weight, strength, and workability, makes aluminum an important cost-cutter in electrical equipment and systems.

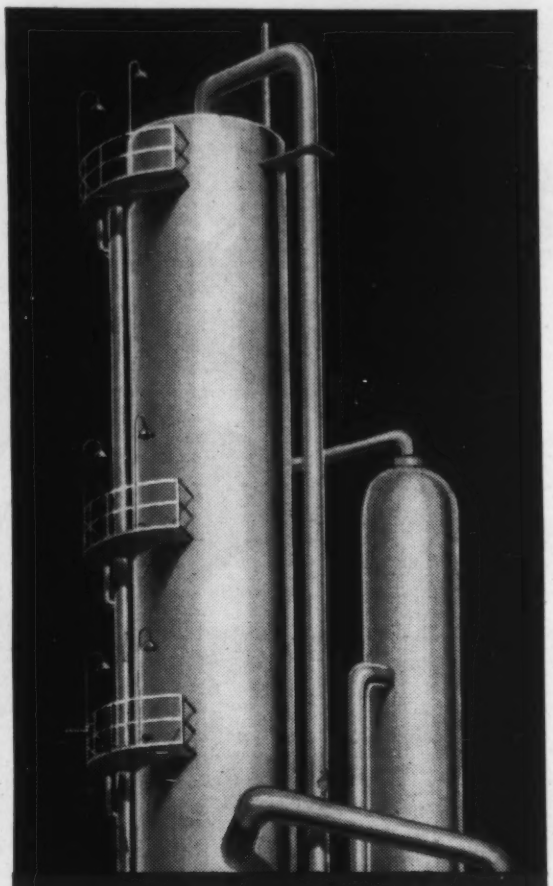
Finish Variety—No other metal can be finished in so many different ways, for so many different effects. You can achieve a brightly-colored or clear finish by anodizing. Aluminum can also be electroplated, painted, porcelainized.

REYNOLDS



Easily Machined and Finished

High Thermal Conductivity



Corrosion-Resistant

because it's versatile

You can finish aluminum by polishing, buffing, embossing, scratch-brushing, spin finishing —by just about any mechanical method. Or you can leave it unfinished, and still have an attractive product.

High Thermal Conductivity—Aluminum conducts heat rapidly and efficiently, thus, it is ideal for air-cooled engines, heat exchange elements, evaporators, cooking utensils. Another characteristic of aluminum is its low emissivity —it retains heat, making it more efficient for air ducts.

Corrosion-Resistance—Aluminum won't rust. But equally important is the fact that aluminum will keep its brightness and strength when handling many chemical agents that attack other metals. This is why so much aluminum piping, jacketing, tanks, vessels, and structurals are used in the chemical and petroleum fields.

Get the details on all of the characteristics and properties of aluminum and its alloys, and on how it can improve your products, cut your costs. Contact the Reynolds Design and Engineering Service, through your local Reynolds office.

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MAGNESIUM WELDABILITY: boon to efficient design

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MAGNESIUM, with its excellent weldability, offers many opportunities for efficient design. It is easily welded by inert-gas shielded-metal arc (both tungsten arc and consumable electrode types), as well as by gas and electric resistance (spot, seam and flash). High strength welds and joint efficiencies as high as 95% are common. Magnesium can also be joined by all conventional mechanical fastening devices or it may be bonded by adhesives.

INERT-GAS SHIELDED-ARC WELDING. Arc welding provides an efficient means of joining both cast and wrought magnesium alloys. Any joint commonly used in the arc welding of steel may be used when welding magnesium. Very thin sections can be arc welded, as well as very thick plate.

ARC WELDING provides an efficient means of joining both cast and wrought magnesium alloys.

This method requires no flux and permits high welding speeds with accurate control of the weld bead. Either direct or high frequency alternating current may be used, depending on thickness of material.

CONSUMABLE ELECTRODE WELDING. This inert-gas shielded-metal arc process features the use of a consumable magnesium electrode and a high current density arc with inert gas shielding. It permits high welding speeds and high metal deposition rates with sound welds. Properties are better than those of tungsten arc welds. Consumable electrode welding is a semi-automatic process, suitable to large scale repetitious welding. All the common types of joints can be welded by this method but it seems particularly suited to butt and fillet welds.

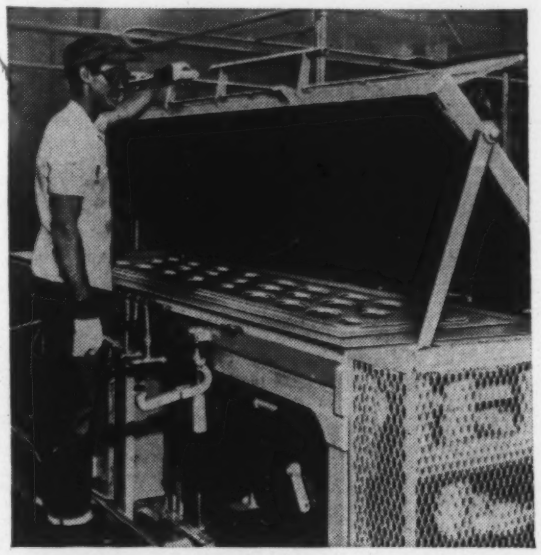
SPOT WELDING. Spot welds in magnesium have excellent static strength with slightly lower fatigue strengths than for riveted joints. The designs for spot welding magnesium are similar to those used on aluminum. Both AC & DC spot welders of the type used for aluminum may be used for magnesium.

SEAM WELDING. Seam welds are made in magnesium in much the same manner used for spot welding. Continuous or intermittent type welds have strength properties comparable to those obtained in spot welds.

FLASH WELDING. Flash welding has not been used extensively in joining magnesium in production, but enough experience in small scale work with this process indicates that it can be adapted to high production joining. Virtually the same equipment and techniques used to flash weld aluminum are utilized for magnesium.

DIP BRAZING. This method of joining magnesium alloys by submerging them in a molten flux has advantages over welding in some applications. It causes no shrinkage or warping, thus making it ideal for jobs in which close tolerances are mandatory. The process is finding particularly extensive use in electronic applications such as wave guides.

ADHESIVE BONDING. The uninterrupted, continuous joints possible with adhesive bonding have aroused considerable interest in many industries, particularly aircraft.



ADHESIVE BONDING of magnesium offers many advantages where fatigue strength is important.

Here's why:

(1) Better fatigue characteristics. (2) Permits use of thinner gauge magnesium than riveting thus allowing greater weight saving. (3) Adhesive acts as an insulator between dissimilar metals in the joint. (4) Permits smoother surfaces for aerodynamic uses. (5) Better production assembly is possible because large areas can be joined at one time.

MECHANICAL JOINING. Magnesium can be joined mechanically by any of the conventional fasteners and various types of inserts. The procedures employed are essentially the same as those used for other metals. For best results, however, some special design considerations may be necessary. These are discussed in detail in the book, "Joining Magnesium", described below.

JOINING MAGNESIUM, a 144-page handbook, discusses all methods of joining magnesium alloys. Includes factual information on weld properties, design of joints, proper equipment and procedures. Also contains numerous photos, tables and mechanical detail drawings. For your copy, contact the nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1454J-2.

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Weldability—Welding is the only technique that we can use to join two pieces of metal so that they act as a single piece of metal.

Not *all* metals. Steel stands alone as the most weldable of all practical metals. Not *all* steels, but most of them can be welded without any sacrifice of strength or elastic behavior. More than that, steel can usually be welded without special precautions, without critical timing procedures, without excessive heat input, without elaborate and corrosive fluxes, without color change in the base metal, and with little danger of cracking. Welding engineers deserve most of the credit for the fact that steel can be welded so easily. With their help, steel producers have made many important break-throughs.

Before the 1930's, carbon and manganese were the main strength-producing elements in steel. Designers wanted stronger steels so they could build lighter structures—and they wanted to *weld* these steels because there is no lighter fastening system. But as the carbon content was raised to strengthen the steels, the weldability decreased and designers were handicapped because they had to fasten "light-weight" high carbon steels with heavy rivet and gusset-plate assemblies.

In 1933 United States Steel introduced the first *low carbon*, high-strength, low-alloy steel—USS COR-TEN Steel—and later USS TRI-TEN Steel. Both steels achieved 50,000 psi minimum yield strength with alloying elements other than carbon, and could be welded with normal procedures. The world of alloy steels was brightened, too, with the introduction a few years ago of USS "T-1" Steel, a constructional alloy steel combining tremendous strength (100,000 psi min. yield strength), toughness *and* weldability without requiring preheating or stress relief.

No matter what combination of properties you desire in a steel, there is a weldable steel that will do the job. In fact, there is theoretically *one* best steel for any application, and it can be selected from our family of Steels for Design: Carbon, High Strength, Alloy and Stainless. If you could use help in finding it, check United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel

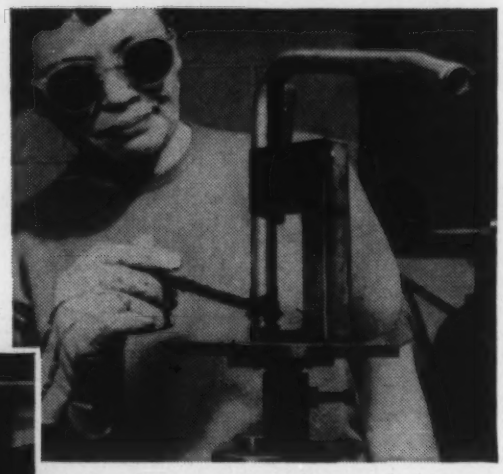
STEELS FOR DESIGN

Lower Left—Problem: Design butt-weld fittings for high-pressure oil and gas lines. Solution: Designer used USS TRI-TEN Steel, a high-strength, low-alloy steel particularly noted for its weldability. Pay-off: Fittings made lighter due to thinner plates; welding was fast and easy; less weld metal was needed; and the weld was as strong as the parent metal.

Lower Middle—Problem: Build a bedplate for a printing press requiring 534 welds. Solution: Builder used USS "T-1" Constructional Alloy Steel. Pay-off: Tremendous strength and toughness of "T-1" withstands thunderous impact from high-speed printing rollers and cutting knives—*and not one weld has failed.*

Lower Right—Problem: Convert a concrete reservoir into a storage area for 2,000,000 gallons of ammonium nitrate. Solution: Reservoir was lined with corrosion-resistant USS Stainless Steel sheets. Pay-off: Quick, easy installation because the Stainless sheets were welded right on the job—3½ *miles* of lap seams were welded and only two tiny imperfections were found when the welds were vacuum tested.

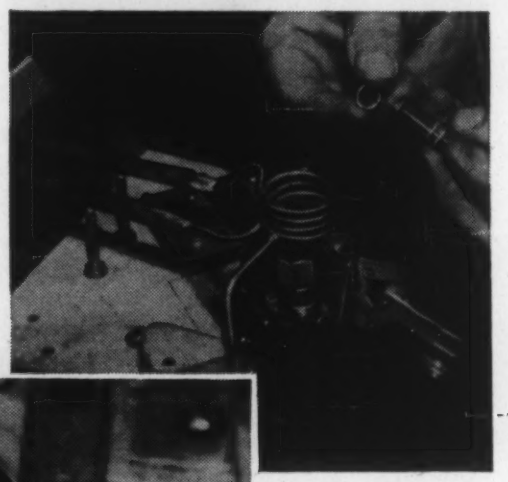
USS, "T-1," Cor-Ten and Tri-Ten are registered trademarks

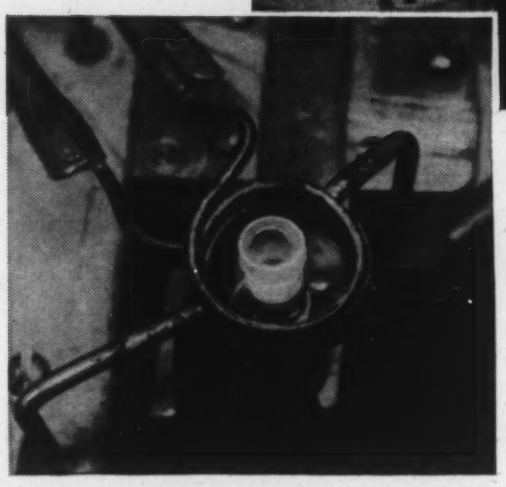


B-1 Flux is particularly effective in removing refractory oxides such as those formed in stainless steels.

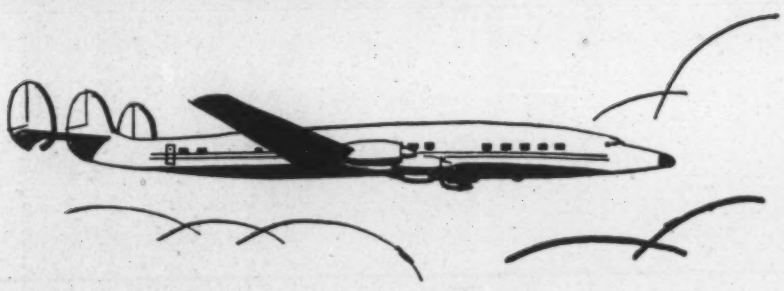
Here operator applies gas-air torch, hand-feeding BRAZE 541 to joint.

Operator fits preformed ring of BRAZE 541 prior to fluxing. This is a hose and tube assembly for an oil line.





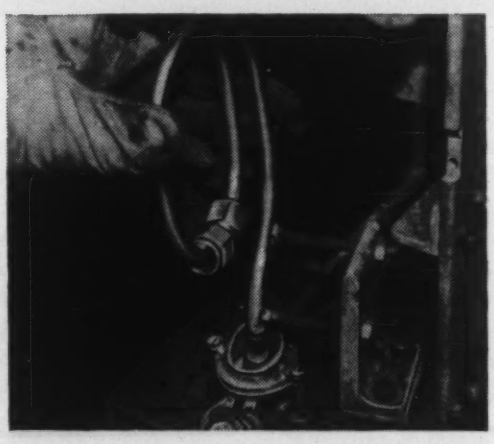
Oil-bearing unit under induction heating.



Here's How Stainless Steel Fuel Systems Benefit From

HANDY & HARMAN SILVER BRAZING

Tube Processing Corporation, Indianapolis, Indiana, makes aircraft and missile fuel systems and, if anything has to be more failure-proof than a fuel line assembly in an airplane, you name it. The units shown here are made of 410 stainless steel tube and 321 stainless steel fittings; when they're joined, they must be joined permanently. Exhaustive tests, including X-ray, pass on each assembly before final acceptance.



Operator placing oil line (of another type) in induction heating ring.

To meet all requirements: strength, ductility, liquid and airtightness, production speed and economy, Tube Processing uses Handy & Harman's special alloy BRAZE 541 (formerly Alloy 4772) and HANDY B-1 FLUX.

Developed strictly for brazing stainless, BRAZE 541 is one of many Handy & Harman brazing alloys—both standard and special—made to do a specific job and do it better than any other metal-joining method.

Name your product and the metals it's made of, the chances are very good indeed that one of Handy & Harman's silver brazing alloys can join it better than the method you now employ. Better from every aspect: economy, speed, strength, conductivity, labor savings. Put your product in these pictures for the same benefits.

An exclusive additional benefit is Handy & Harman's application Engineering Service. This is a service that exists to show you how these benefits can best be applied to your product. We invite you to take advantage of both Handy & Harman Brazing Alloys and Engineering Service.

GET THE FACTS

Technical Bulletins T-1 and T-2 give the general characteristics of silver brazing alloys plus the compositions, melt and flow points of 32 separate alloys. Write for your copies.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN QUALITY SERVICE

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

DISTRIBUTORS IN PRINCIPAL CITIES

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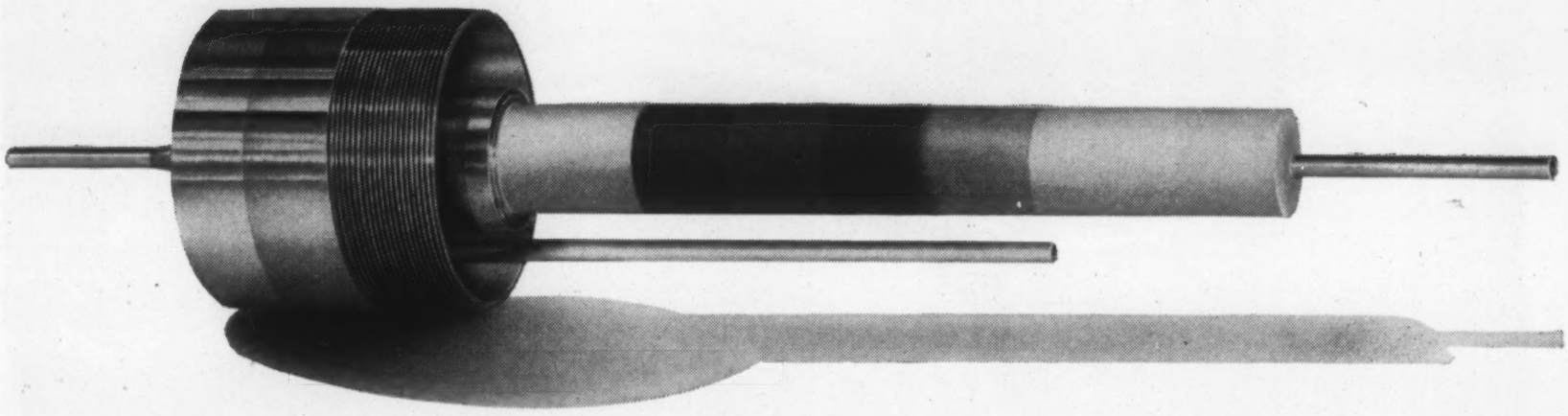
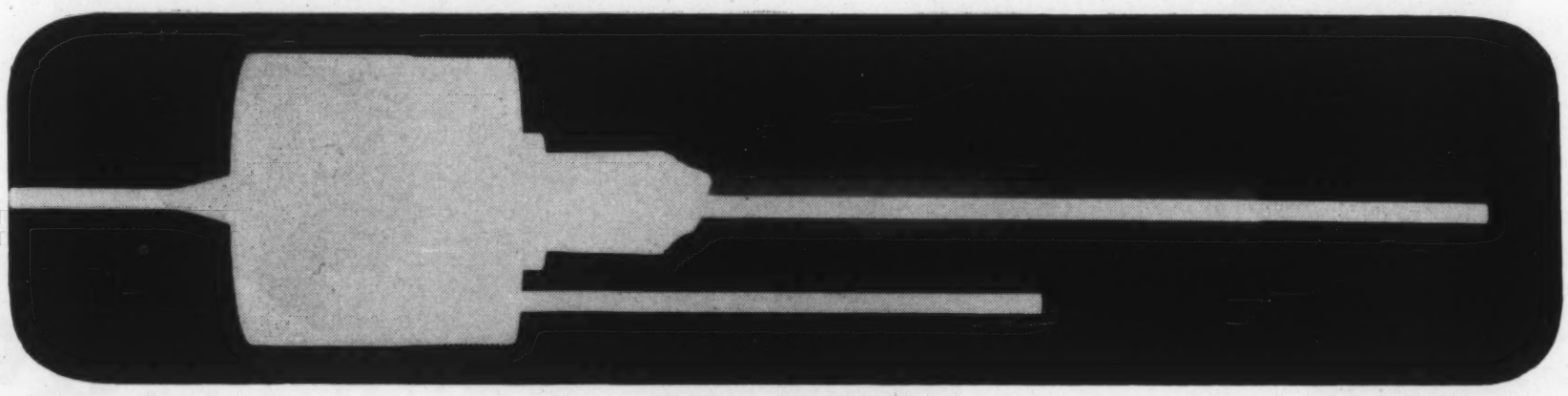
MONTREAL, CANADA

For more information, turn to Reader Service Card, circle No. 395

Seal unit of one of the repeaters of a transoceanic telephone cable.



It has a 20-year job 3 miles under the sea



Radiography reveals no foreign particles or voids in molded areas, shows the ultimate contact of the molded insulation with the central conductor.

Radiography shows the rubber seal and molded parts are ready to take it

EVERY 40 MILES along a transoceanic telephone cable, there is a repeater—an electronic masterpiece designed to boost the message along and made to operate 24 hours a day for a minimum of 20 years.

Any foreign particles in the molded parts of the seal could reduce its performance. And with sea water pressures up to 8000 lbs. p.s.i. to resist, the adherence of the rubber seal areas to the central conductor and outer metal shell must approach perfection.

Radiography assists Western Electric to make sure that each repeater measures up to specification.

Using Kodak Industrial X-ray Film, Type AA, the radiographer can inspect each repeater thoroughly, and quickly. This film has the sensitivity and speed to enable the work to be done even with low-power x-ray equipment.

In all applications, Type AA Film is producing quality work in far less time. It is extending the service of present x-ray equipment, and increasing production with gamma-ray sources.

Have your x-ray dealer or Kodak Technical Representative tell you about it. It saves time and money.

EASTMAN KODAK COMPANY, *X-ray Division*, Rochester 4, N. Y.

Kodak Industrial X-ray Film, Type AA

Read what Kodak Industrial X-ray Film, Type AA, does for you:

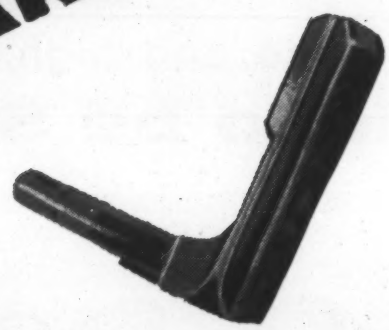
- Speeds up radiographic examinations.
- Gives high subject contrast, increased detail and easy readability at all energy ranges.
- Provides excellent uniformity.
- Reduces the possibility of pressure desensitization under shop conditions.

Kodak
TRADE MARK

For more information, turn to Reader Service Card, circle No. 394

FOR THE MACHINERY PART

THAT TAKES THE BEATING



A cut-off knife made of HAYNES STELLITE alloy No. 19 slices through molten glass at 2200 deg. F. Despite the intense heat of the glass being molded into tumblers, and the severe erosive action of the glass on metal, the cut-off knife maintains a 0.015-in. clearance between itself and the mold ring . . . *far longer than any other material ever used.*

Are you looking for a tough metal part to improve your machinery? It will pay you to look into HAYNES alloys. There are more than 15 from which to choose, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. Parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist many conditions of wear, heat, or corrosion.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

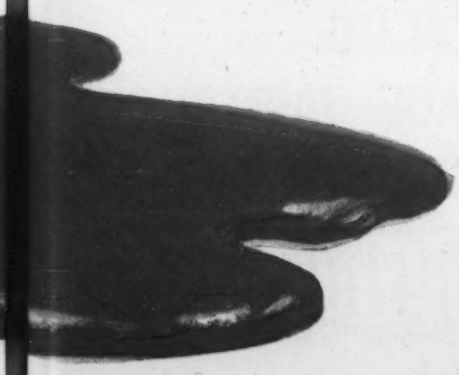
Division of Union Carbide Corporation

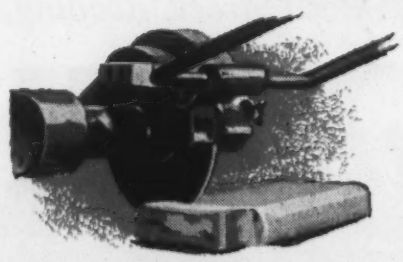
Kokomo, Indiana

UNION CARBIDE

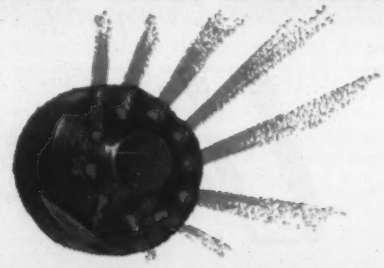
The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS





Tough, long-lasting metal-cutting saws over 20 inches in diameter, made of HAYNES STELLITE alloy sheet, slice the tops off copper ingots.



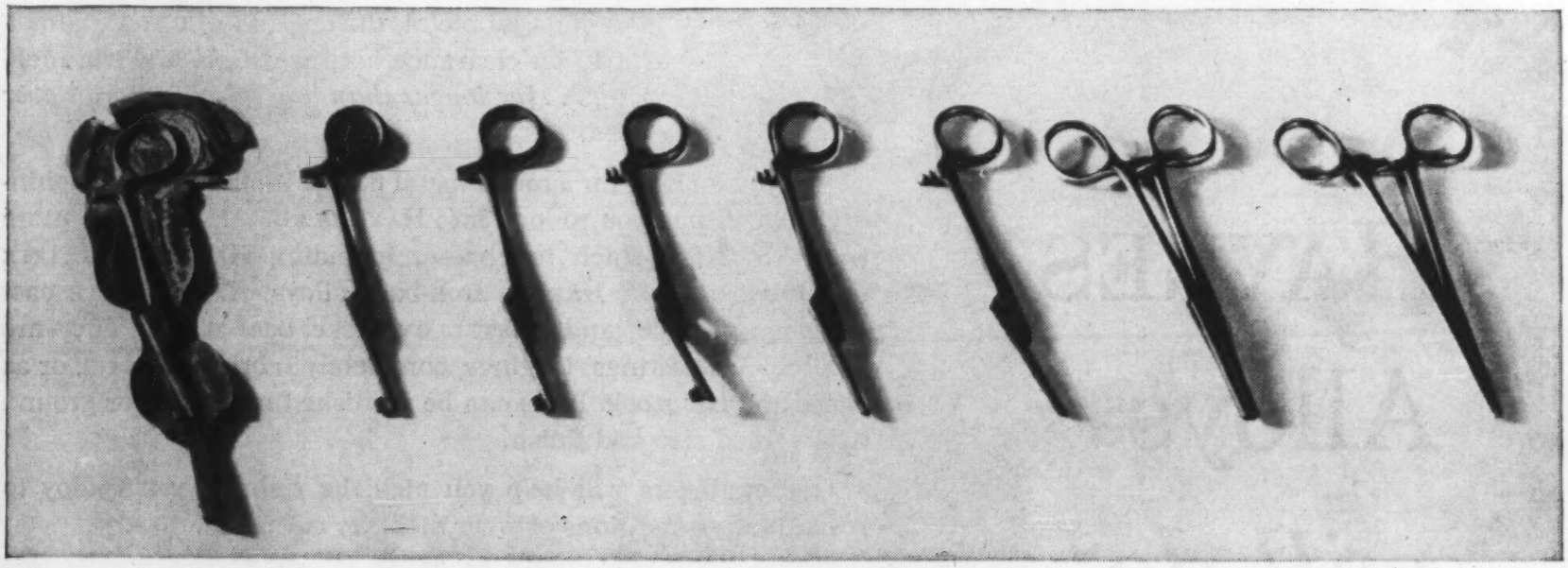
Steam atomizer fuel burner nozzles of HASTELLOY alloy C resist corrosive agents and erosion for months, retaining essential contours.

High-temperature strength and corrosion resistance of diesel combustion chambers made of HASTELLOY alloy C make them "good for life of the engines."

For more information, turn to Reader Service Card, circle No. 396

for strength, corrosion resistance and high finish

...it had to be Stainless



All orders for stainless steel for these artery forceps specify "Carpenter" because of "uniformity from shipment to shipment". Freedom from seams and excellent machining to close tolerances are other reasons given by the fabricator. The stainless is specially processed to meet the rigid specifications. By specifying Carpenter you can take the pressure off both designer and fabricator. High temperatures and stress variations are no longer problems. We'll back up our success stories with technical data and on-the-job service. Call your Carpenter representative for information on the stainless you need. The Carpenter Steel Company, 135 W. Bern Street, Reading, Pa.

Carpenter STEEL

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.

For more information, turn to Reader Service Card, circle No. 389

Developed by Du Pont research

NEW FAIRPRENE® DIAPHRAGM MATERIAL

demonstrates outstanding resistance to "sour gas," ozone and aromatic fuels

Du Pont research has developed an outstanding "Fairprene"† coated fabric for diaphrams in fuel pumps and carburetors. This new "Fairprene" shows remarkable resistance to the effects of oxydized gasoline, or "sour gas," and ozone. It is exceptionally resistant to swelling in contact with highly aromatic fuels. In addition, this new "Fairprene" coated fabric shows superior abrasion resistance and retains its properties to -65°F.

New "Fairprene" ozone and fuel-resistant coated fabric is offered in widths to 41" and thicknesses from 0.004" to 0.050", with cotton, rayon or nylon fabric inserts. Mail coupon or write for your free sample plus complete specifications and prices. E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division MD-129, Wilmington 98, Delaware.

CONSTRUCTIONAL AND PHYSICAL PROPERTIES††

Quality No.	22-005FO	21-009FO	22-006FO
FABRIC BASE	NYLON	COTTON	NYLON
Thickness	.013"	.013"	.050"
Tensile Strength—Lbs./Inch, Min.	75 x 75	80 x 80	300+ x 300+
Tear Strength—Lbs., Trap., Min.	2 x 2	2 x 2	25 x 25
Burst Strength—PSI, Mullens, Min.	125	125	500
Ozone Resistance at 60 Parts Per Million*	OK 208 Hr.	OK 208 Hr.	OK 208 Hr.
Fuel Resistance—Volume Change after 72 Hrs. at Room Temp. in ASTM High Aromatic Fuel**	+3.3%	+9.4%	+20.9%

*Ordinary diaphragm materials fail in 15 minutes under this test.
**Ordinary diaphragm materials swell about 20% under the same conditions.
††The above data are based upon tests on production experience and should not be used as specifications.

DU PONT INDUSTRIAL COATED FABRICS SHEET STOCKS · CEMENTS

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

†*"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements*

▶ Mail coupon for free sample of new "Fairprene" ozone and aromatic fuel-resistant diaphragm material . . .

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Dept. MD-129, Wilmington 98, Delaware

☐ Please send free sample of new "Fairprene" diaphragm material with high ozone and aromatic-fuel resistance.

☐ Please send bulletin on "Fairprene" industrial coated fabrics.

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For more information, turn to Reader Service card, circle No. 499

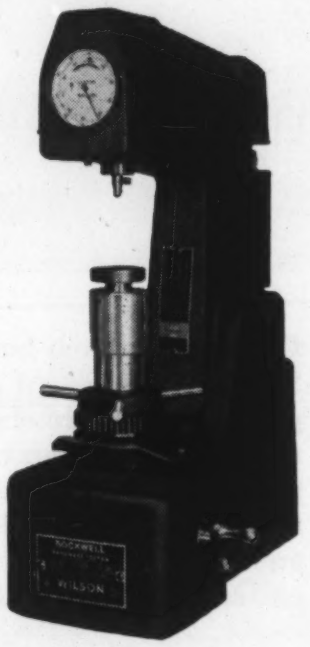
WILSON "ROCKWELL"

HARDNESS TESTERS • *WORLD'S STANDARD OF ACCURACY*

ACCO for Better Values

Equipment for *EVERY Hardness Testing Requirement*

WILSON "ROCKWELL" HARDNESS TESTERS ...ACCURATE AS A PRECISION BALANCE



No matter what your hardness testing requirements are, there's a WILSON "ROCKWELL" instrument to do the job. Choose from this complete selection of hardness testers:
"*ROCKWELL*"—for most hardness testing functions.
Superficial—for extremely shallow indentations.
Twintester—combines functions of "ROCKWELL" and "ROCKWELL" Superficial testers.
Semi-Automatic (manual feed) and Fully Automatic—for automatically classifying tested pieces as CORRECT, TOO HARD, or TOO SOFT—at test rates up to 1000 pieces per hour.
Special Machines—for testing large objects, obtaining internal readings, and other unusual applications.

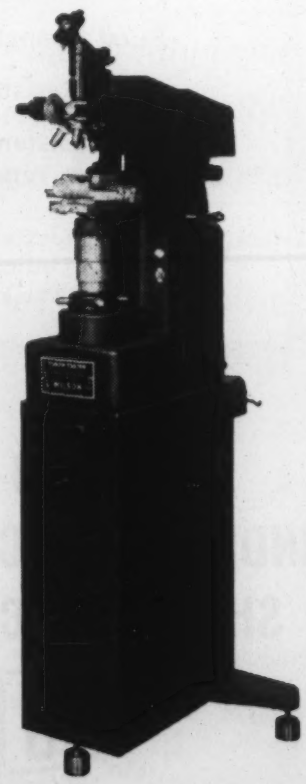
ALL WILSON "ROCKWELL" hardness testers provide these advantages:
Accurate performance—precision built, with exact calibration, for consistently correct results.
Long life—durable as a machine tool.
Easy operation—even an unskilled operator can get perfect readings. All controls conveniently grouped.
Easy maintenance—interchangeable mechanisms, with spindles mounted on oil-less bearings.

DIAMOND "BRALE" PENETRATORS... perfect testing every time

A perfect diamond penetrator is essential to accurate hardness testing. Since one point of hardness on the "ROCKWELL" scale represents only 80 millionths of an inch penetration—only 40 millionths on a Superficial tester—the slightest imperfection will cause a false reading.

Only *perfect* Wilson Diamond Brale Penetrators are sold. Each diamond is flawless, with no chips or cracks. It's cut to an exact shape. Microscopic inspection of every diamond—one at a time—assures this perfection—and assures you of accurate hardness testing every time.

TUKON TESTER ...for precision MICRO & MACRO testing



The TUKON Tester measures extremely shallow indentations. It's used, for instance, by manufacturers of watches, hairsprings, needles, and fine wire. Laboratories use the TUKON for tests on individual crystals or particles of microscopic size. Producers of coatings, film, ceramics, and many other materials have made good use of the TUKON.

Three models are available to meet your individual requirements. TUKON Testers use both the Knoop and 136° Diamond Pyramid Indenter. Each TUKON Tester is a self-contained hardness testing instrument— no accessory equipment is needed. Knife edges and levers of fixed length are used throughout for application of exact load and freedom from internal friction.

A COMPLETE LIBRARY of helpful information

A wide variety of bulletins describes the many instruments, accessories, and services Wilson offers. Write for your choice:
DH-325—WILSON "ROCKWELL" Hardness Testers • DH-326—"ROCKWELL" Superficial Hardness Testers • DH-327—Special "ROCKWELL" Testers, including Automatic and Semi-Automatic models • DH-7—TUKON Applications • DH-328—TUKON Testers.

ACCO **WILSON**
MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE
230-E Park Avenue, New York 17, N. Y.

For more information, turn to Reader Service card, circle No. 443

Tool Steel Topics

ific Coast Bethlehem products are sold
em Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

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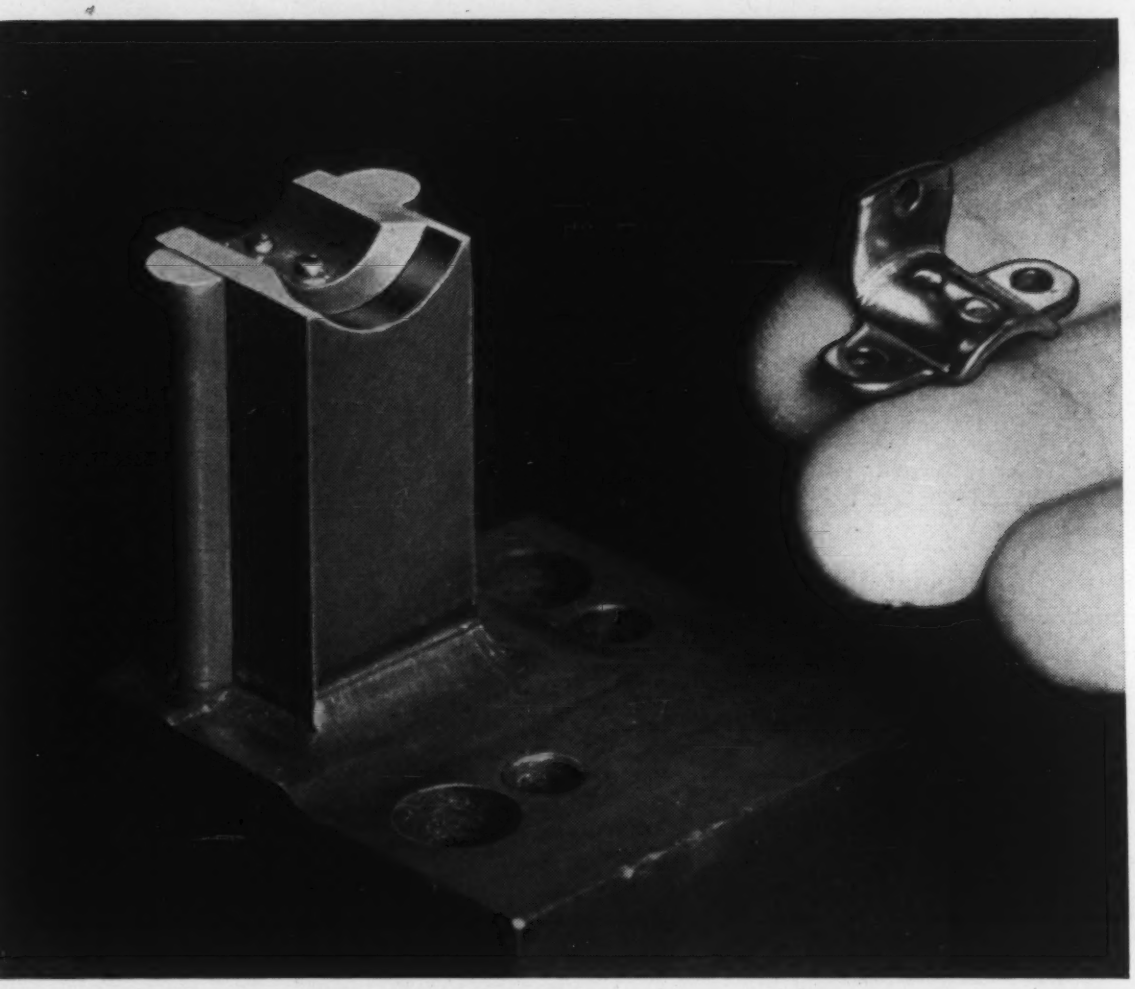
Bethlehem Steel Export Corporation



1½ million pieces with Lehigh H ...that's a long run in any league!

At Harvey Hubbell, Inc., Bridgeport, Conn., they were using a competitive grade of tool steel to form cord-clamp sections made from Grade 1010 steel strip. But each time they hit an average figure of 700,000 pieces, the die cracked, and had to be replaced. The manufacturer decided to call in Lindquist Steels Inc., a local distributor of Bethlehem tool steel.

"With the finished part only .060 in. thick, we ought to do better than 700,000 pieces. What do you suggest?"

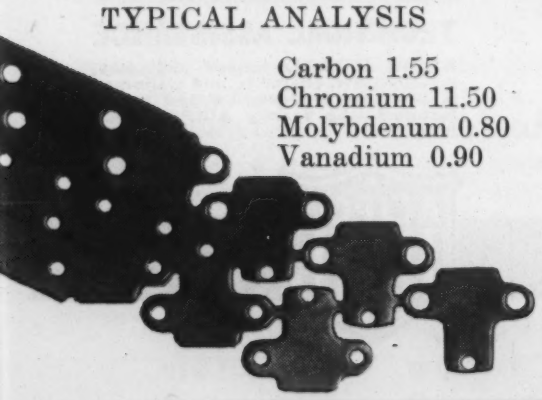
The distributor studied the operation, the cracked die, and the finished part. "I'd recommend Lehigh H," he said. "It has the strength you need in a forming operation of this sort." The Lehigh H was put on the job and produced 1½ million pieces without any trouble.

Lehigh H is our high-carbon, high-chromium, air-hardening tool steel. It's a grade with outstanding wear-resistance and toughness. And it's also a deep-hardening steel with high compressive strength.

The best way to evaluate Lehigh H is by putting it to work—not in an easy job, but in a tough one. Your Bethlehem tool steel distributor carries Lehigh H in stock, and will see that it's delivered promptly. Get in touch with him.

TYPICAL ANALYSIS

Carbon 1.55
Chromium 11.50
Molybdenum 0.80
Vanadium 0.90



BETHLEHEM TOOL STEEL ENGINEER SAYS:

Don't Use Fresh Water For Quenching Tools

Fresh water, regardless of its source, contains dissolved gases which make it unsuitable for quenching tools. When tools are quenched in fresh water, gas is liberated at the surface of the tool. Gas pockets thus formed may prevent contact between tool and water, resulting in soft spots from ineffective quenching. Soft spots are undesirable because of their low hardness, and also because a quench which produces them may also cause cracking of the tools.

Soft spots, and tool cracking associated with soft spots, can be avoided by quenching in water which has been previously boiled, to remove the dissolved gases. If water cannot be boiled, quench a large amount of hot "dummy" material to expel the gases. As a further precaution against soft spots, it is preferable to use a 10 pct brine solution instead of water. It is also suggested that the dissolved gases be expelled from the brine solution before use.

USE DURAMOLD FOR COLD-HOBBING

Bethlehem's Duramold tool steels, in Grades A and B, are ideal for cold-hobbing plastic dies because they are free from injurious surface and internal defects. Duramold A, an air-hardening grade, is annealed to 109 max Brinell. Duramold B hardens in oil, and hobs more readily than Duramold A. It is annealed to 100 max Brinell, and has an addition of boron to increase the core strength.

For more information, turn to Reader Service Card, circle No. 446

Versatile ACIPCO SPUN TUBES

Stainless steel, carbon steel, alloy iron or special analyses—versatile ACIPCO tubes are "custom-spun" to the exact physical, chemical and metallurgical specifications required by design, manufacturing and end-use conditions.

Because they are centrifugally spun, the metal grain structure of ACIPCO tubes is dense, non-directional and porosity-free. This *superior* grain structure not only makes ACIPCO tubes easier to machine to close tolerances, but also results in greater strength and durability. In addition, the inherent dimensional stability and concentricity of ACIPCO tubes make dynamic balance easier to attain in finished products.

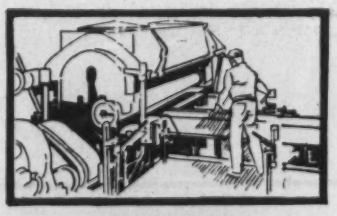
ACIPCO'S complete, integrated facilities for casting, heat-treating, machining, fabricating and testing offer the additional advantages of "one source—from start to finish" service.

Call or write today for information about ACIPCO tube applications in your field, or for expert technical assistance on your specific tubular metal problem.

SIZE RANGE: Lengths up to 410" have been produced to meet modern machinery requirements. OD's from 2.25" to 50"; wall thicknesses from .25" to 4".

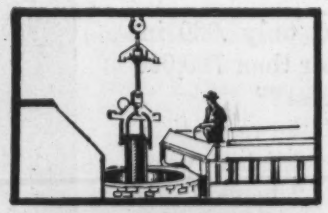
ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

FINISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.



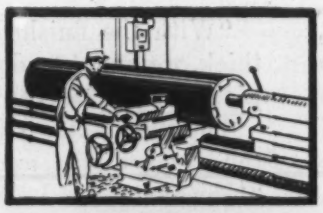
SPINNING

ACIPCO tubes are centrifugally spun to exact physical and metallurgical specifications. Thus, the exact size and metal analysis your process or project requires is assured.



HEAT TREATING

Modern equipment for uniform, controlled heat treating and quenching is an ACIPCO advantage for users of steel tubes where specific physical, mechanical and other metal properties are required.



MACHINING

ACIPCO'S machine shop, one of the South's most completely equipped, performs a full range of machine shop operations including turning, boring, drilling, facing, grinding, metallizing, polishing and honing.

FABRICATION

Complete, integrated facilities for machining, welding, finishing and heat treating of tubular parts save time and expense for ACIPCO customers.

TECHNICAL ASSISTANCE

A staff of highly trained engineers, metallurgists, chemists, and craftsmen is available to designers and manufacturers who specify ACIPCO spun tubes.

Special Products Division

AMERICAN CAST IRON PIPE CO.

PHONE AL 1-8121, EXT. 285 • BIRMINGHAM, ALA.

For more information, turn to Reader Service card, circle No. 489

Fore more information, circle No. 450 ➤

Optics Mfg. offers lifetime guarantee for projector case made of MARLEX*

"We picked MARLEX for our new slide projector case and height adjustment knob because it is the least expensive type of plastic material that has the required rigidity, resistance to heat and impact, colorability and gloss," says Herbert R. Leopold, Vice President of Optics Manufacturing Corp., Philadelphia, Pa.

"Our new Opta-Vue is the first projector on the market with a thermoplastic housing. Since this was a design innovation, we had to be sure to select a suitable resin, so we tested them all. One "high-impact" plastic lasted just 4 hours in our heat test before it melted! Another "heat-resistant" plastic cracked in several places in our drop test. MARLEX was the only material tested that matched all our specifications and passed all our tests. In fact, we advertise a lifetime guarantee for all MARLEX projector components!"

Whether your major interest is injection moldings, vacuum moldings, extrusions, filaments, sheet or transparent film, you will find that MARLEX is the best thermoplastic resin for the job. In fact, no other material serves so well, and so economically in so many different applications.

How can MARLEX serve you?

*MARLEX is a trademark for Phillips family of olefin polymers.

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma

A subsidiary of Phillips Petroleum Company

PLASTICS SALES OFFICES

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GEneva 4-7600	Digby 4-3480	FRanklin 6-4126	TErrace 4-6600	RYan 1-6997	EMerson 8-1358

EXPORT: 80 Broadway, Suite 4300, New York 5, N.Y.

MARLEX® Phillips 66 A PHILLIPS 66 PLASTIC

This alloy "shopping list" saves many a day for busy metallurgists!

AISI		AMS			SAE	
302	410	5333	5376	5631	30302	51442
303	414	5334	5378	5640	30303	51446
304	416	5350	5380	5643	30303F	60303A
308	420	5351	5382	5645	30304	60304
309	430	5352	5385	5665	30310	60310
309+W	430F	5354	5386	5700	30316	60316
310	431	5355	5388	5710	30321	60347
316	431A	5358	5389	5735	30347	60410
321	436	5360	5392	5765	51410	60420
327	440A	5361	5393	6270F	51414	60442
329	440B	5362	5394	6274F	51416F	60446
330	440C	5363	5526	6280C	51420	70310
331	440F	5366	5537	6350	51430	70310A
347	442	5369	5610E	6382	51431	70327
403	446	5370	5616	6428	51440A	70330
406		5372	5621	7834	51440B	70331
		5373	5628		51440C	70446
		5375	5630		51440F	

MISCELLANEOUS

Armco 17-4PH • GMR 235 • Inconel* • Invar • Monel* • NiResist* IA • NiResist* IIA • NiResist* III • Waspalloy

*® International Nickel Co.

You name the alloy... we'll produce to your specs. —in record time!

THE watchword of CANNON-MUSKEGON is "CONTROL." Careful selection of the finest raw materials . . . rigid melting procedures . . . complete chemical and physical testing facilities, plus closely supervised handling — produce alloys to your most exacting standards. More than 100 special and standard alloy analyses are produced each year.

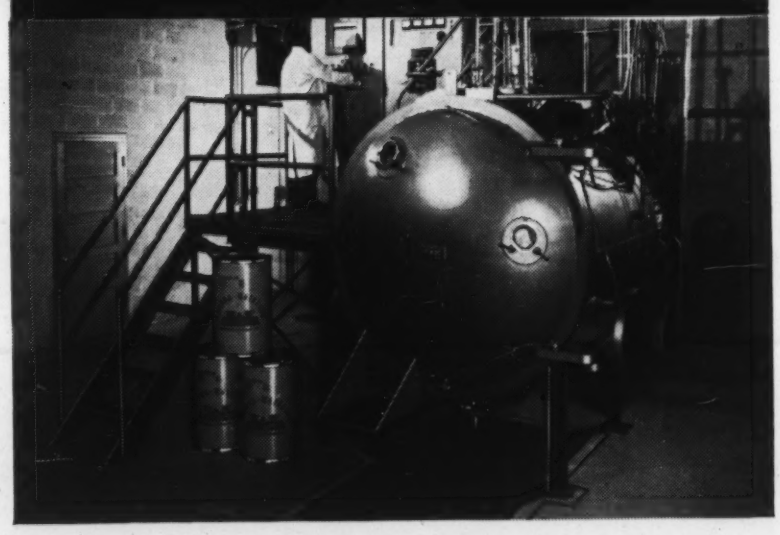
The alloy list above is typical of production "regulars" for scores of users in all industrial fields. If you don't see what you need — remember, our facilities are open to "tailor" alloys to your specific needs. We'll also recommend proper in-plant handling and heat treating procedures to assure the desired physical and chemical properties in your final product.

FOR IMMEDIATE REFERENCE — write for your personal copy of Cannon-Muskegon's 6-page handbook for metallurgists, giving you data on both UltraMet and MasterMet alloy service.

ULTRAMET VACUUM-MELTED ALLOYS FOR INDUSTRY

MASTERMET CERTIFIED ALLOYS FOR INDUSTRY

and CANNON-MUSKEGON offers you both vacuum and air-melting facilities for cobalt-, ferrous- and nickel-base alloys in a wide variety of cast forms



UltraMet alloys are produced in this latest design vacuum melting furnace — production center for a virtually unlimited variety of high temperature, corrosion resistant alloys for severe-stress applications.

CANNON-MUSKEGON CORPORATION

2873 Lincoln Avenue • Muskegon, Michigan, U.S.A.

METALLURGICAL SPECIALISTS

For more information, turn to Reader Service Card, circle No. 377

For more information, circle No. 375

Pay less for more strength! Tenzaloy the self-aging aluminum alloy needs no heat treatment! If your aluminum castings are too large or too intricate for heat treatment, if your heat treating facilities are limited, if you need superior strength than you get from ordinary heat-treated alloy demand "Federated Tenzaloy" developed by Federated to meet the need for a superior aluminum alloy that ages at room temperature. Tenzaloy eliminates rejects due to warpage, expansion, and internal stresses caused by quenching. Tenzaloy finished properties are stable, proved by conclusive test data over a ten year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand cast and plaster molds and many permanent molds. Tenzaloy will not "grow," produces corrosion-resistant castings with excellent polishing characteristics and anodizes clear white. Write for Tenzaloy Bulletin No. 103. Federated Metals Division, 120 Broadway, New York 5. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

FEDERATED METALS DIVISION OF

A.S.A.R.CO

AMERICAN SMELTING AND REFINING COMPANY

TENZALOY is one of a complete series of Federated aluminum casting alloys. A new plant in Hillton, Ill. will soon be in production to satisfy the requirements for Tenzaloy in the mid-west.

HOW CAN YOU USE THE RARE EARTHS?

Find new uses through process and product development research

a report by LINDSAY

If you have been curious about the rare earths and have wondered if they might be useful tools in your own production processes, you may find it rewarding to talk with us.

We can give you a wealth of technical data about the high purity rare earth and yttrium oxides. And we may be able to make suggestions which will be helpful to you in exploring potential applications of the rare earths.

The amazing versatility and unique characteristics of the rare earths are sure to challenge the imagination of your research people. It is quite likely that through research you may find, as so many others have, profitable applications for these materials. The wide variety of uses for the rare earths is indicated by these few examples.

Neodymium . . . in ceramic dielectric applications.

Cerium . . . a stabilizer against radiation browning in glass.

Dysprosium . . . in neutron measuring devices.

Gadolinium and *lanthanum* . . . in maser microwave amplifiers.

Ytterbium, samarium, europium, gadolinium and *lanthanum* . . . as phosphor activators.

Yttrium oxide . . . in an yttrium iron garnet, a ferrimagnetic material, for use in microwave equipment.

Erbium, europium, samarium, dysprosium and *gadolinium* . . . in control rod devices in nuclear reactors.

Most of the rare earth and yttrium oxides, in purities up to 99.99%, are available for prompt deliveries in quantities of an ounce to hundreds of pounds. You can be sure of materials needed for production purposes.

Current prices make high purity rare earths attractive and economically sound for a wide variety of chemical and industrial uses. Lower purity rare earths are more attractive cost-wise and may be suitable for your purposes.

TYPICAL MAXIMUM IMPURITIES IN LINDSAY PURIFIED RARE EARTH AND YTTRIUM OXIDES

ATOMIC NO.	OXIDE	CODE	PURITY	% RARE EARTH MAXIMUM IMPURITIES AS OXIDES
57	La_2O_3. LANTHANUM OXIDE	528 529	99.99 99.997	0.01 Pr, 0.001 Ce. 0.0025 Pr, 0.0005 others
58	CeO_2. CERIC OXIDE	215 216	99.8 99.9	0.2 (largely La + Pr + Nd). 0.1 (largely La + Pr + Nd).
59	Pr_6O_{11}. PRASEODYMIUM OXIDE	726 729.9	99 99.9	1 La + Nd + smaller amounts of Ce and Sm. 0.1 Ce + Nd.
60	Nd_2O_3. NEODYMIUM OXIDE	628 629 629.9	95 99 99.9	1-4 Pr, 1-4 Sm, 0.5-1 others. 0.1-0.4 Pr + 0.1-0.4 Sm + 0.5 others. 0.1 (largely Pr + Sm).
62	Sm_2O_3. SAMARIUM OXIDE	822 823	99 99.9	0.2-0.7 Gd, 0.2-0.6 Eu, and smaller amounts of others. 0.1 (largely Nd + Gd + Eu).
63	Eu_2O_3. EUROPIUM OXIDE	1012 1011	98-99 99.8	1-2 Sm + smaller amounts of Nd + Gd + others. 0.2 (largely Sm + Gd + Nd).
64	Gd_2O_3. GADOLINIUM OXIDE	928.9 929.9	99 99.9	1 Sm + Eu + trace Tb. 0.1 Sm + Eu + trace Tb.
65	Tb_4O_7. TERBIUM OXIDE	1803 1805	99 99.9	1 Gd + Dy + Y. 0.1 Gd + Dy + Y.
66	Dy_2O_3. DYSPROSIUM OXIDE	1703 1705	99 99.9	1 (largely Ho + Y + Tb + small amounts of others). 0.1 Ho + Y + traces of others.
67	Ho_2O_3. HOLMIUM OXIDE	1603 1605	99 99.9	1 (largely Er + Dy + small amounts of others). 0.1 Er + Dy + traces of others.
68	Er_2O_3. ERBIUM OXIDE	1303 1305	99 99.9	1 Ho + Dy + traces Yb and Y. 0.1 Ho + Tm.
69	Tm_2O_3. THULIUM OXIDE	1405 1403	99.9 99	0.1 Er + Yb + trace Lu. 1 Er + Yb + trace Lu
70	Yb_2O_3. YTTERBIUM OXIDE	1201 1202	99 99.9	1 Er + Tm + trace Lu. 0.1 Tm + trace Lu + Er.
71	Lu_2O_3. LUTETIUM OXIDE	1503 1505	99 99.9	1 Yb + Tm + traces of others. 0.1 Yb + Tm + traces of others.
39	Y_2O_3. YTTRIUM OXIDE	1112 1115 1116	99 99.9 99.9+	1 Dy + Gd + traces Tb and others. 0.1 Dy + Gd + traces Tb Approx. 0.05 Dy + Gd.

For detailed information and prices, write for our bulletin "Purified Rare Earth and Yttrium Oxides"

PLEASE ADDRESS INQUIRIES TO

TRONA

LINDSAY CHEMICAL DIVISION

American Potash & Chemical Corporation

276 ANN STREET • WEST CHICAGO, ILLINOIS

For more information, turn to Reader Service card, circle No. 366

Acres of roof deck panels made from USS Galvanized Steel Sheets

—the zinc stays on

Acres of galvanized steel roof and floor panels are made at Fenestra's West Elizabeth, Pennsylvania, plant. These panels find use in schools, office buildings, stores, plants and many other types of buildings. Fenestra uses USS Galvanized Steel because the continuously hot dip zinc coating remains unbroken through all the fabrication processes; cutting, creasing, cold forming, shearing and welding. The zinc stays on to provide the high degree of protection desired.

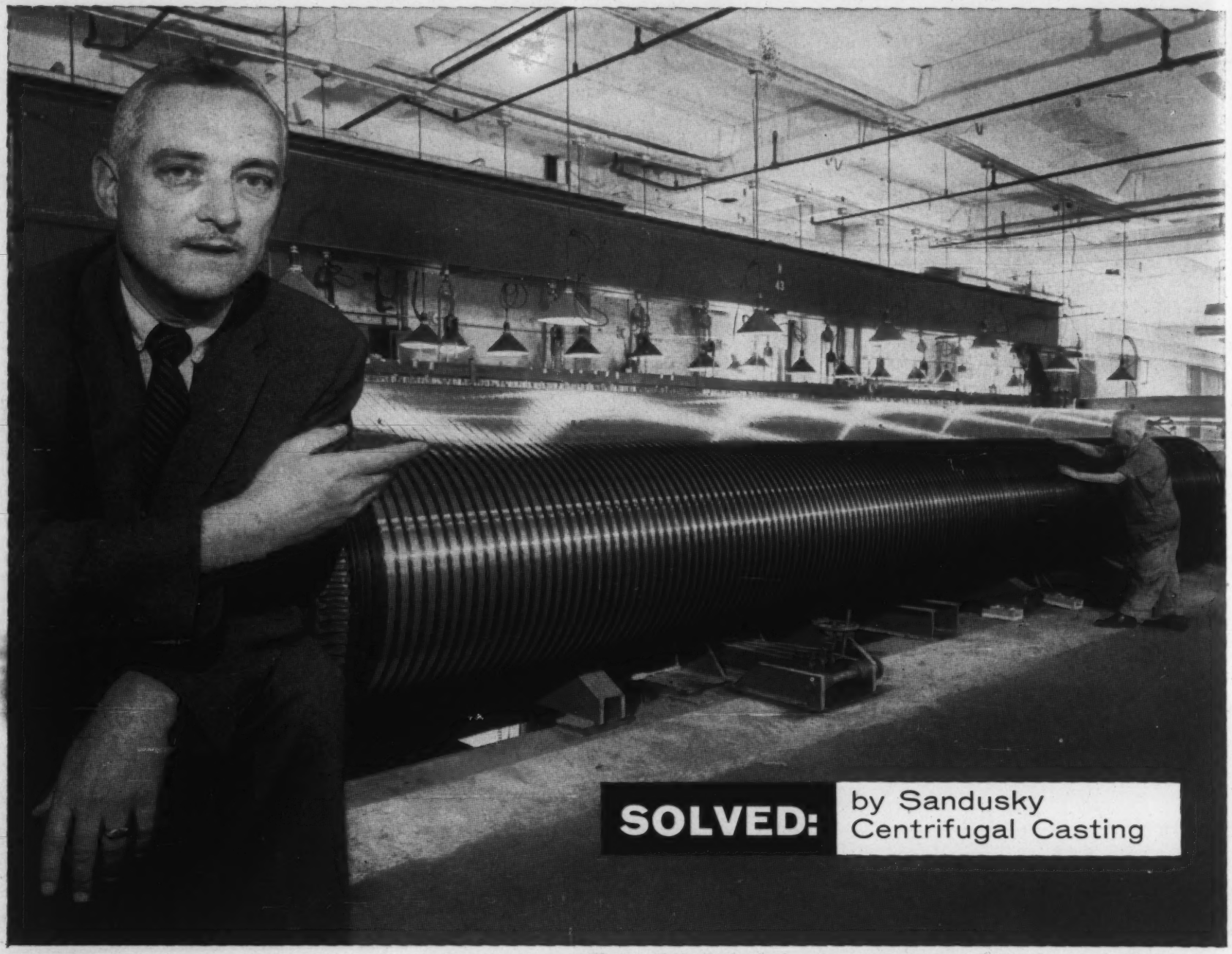
You can get the same results using USS Galvanized Steel Sheets. Call our local sales office or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

Unless otherwise ordered, USS Galvanized Steel Sheets are chemically treated to inhibit the formation of white oxide—sometimes called wet storage stain.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
American Steel & Wire—Cleveland
United States Steel Supply—Steel Service Centers
United States Steel Export Company

USS **United States Steel**



Eastwood-Nealley's chief engineer points out great size of grooved cylinder

Who else could cast this 22-ton cylinder for the world's biggest wire cloth loom?

To weave Fourdrinier wires up to 352″ wide for the world's newest and largest paper machines, Eastwood-Nealley Corp., Belleville, New Jersey, required a cylinder over 30 feet long.

Sandusky supplied this 44,685 lb. roll, centrifugally cast of SAE-1030 steel and rough machined to 363″ in length, 40⅛″ on the O.D., to be used as the backbeam on Eastwood's new wire cloth loom. Since the cylinder had to be machined with 176 extremely smooth 2″ x 2″ stirs (grooves) in which wire is wound, it had to be of *flawless quality*. Otherwise any voids or inclusions exposed by machining would nick the delicate bronze strands and cause the expensive wire cloth to fail.

Eastwood-Nealley's chief engineer, Clemson A. Bower, asserts: *"We chose a Sandusky Centrifugal Casting because only Sandusky could make such a gigantic cylinder without welding. We were confident that our special machining operation would be accomplished without costly re-makes, for in the 12 years we have been using them, we never found a single flaw in a Sandusky Centrifugal Casting!"*

When cylinders or piping are needed in your design, keep Sandusky Centrifugal Castings in mind. We can supply cylindrical products from 7″ to 54″ O.D. and up to 33 feet long—made from a variety of alloys including stainless, carbon and low-alloy steels as well as copper- and nickel-base alloys. Send for free booklet, "Your Solution to Cylindrical Problems."

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

5804 SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

For more information, turn to Reader Service card, circle No. 427

THIS IS GLASS

a bulletin of practical new ideas from Corning

It's cooler inside!

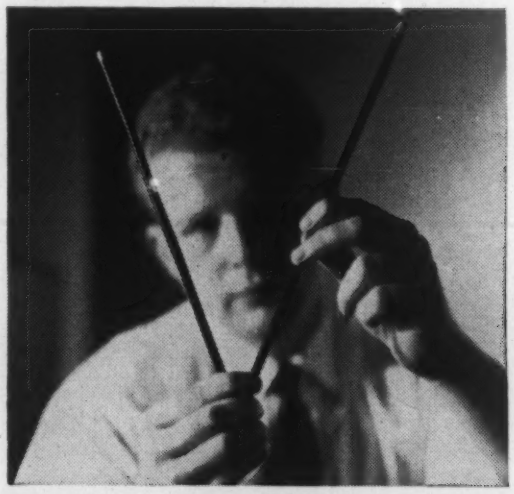
Sitting behind the controls of this crane in a steel mill used to be a hot job. But now cab windows are made of ¼" polished plate that's fashioned from PYREX brand *infrared reflecting* glass.

This glass *bounces* heat away—transmission of IRR (infrared) being as low as 7%, depending on wave length. Yet you can see through these windows since about 75% of visible light is passed. These IRR windows are strong, chemically resistant, and very durable. You can get them in sizes up to 30" x 60". For details (along with data on blue observation glass, PYREX brand glass No. 7740, and VYCOR brand glass No. 7900) ask for PE-34, a 4-page data sheet covering flat glass properties, specifications, and applications.

Hot rod

This has *nothing* whatsoever to do with motor cars. Rather our concern here is a piece of *glass* rod that conducts electricity and produces heat.

The rod is ¼" O.D., made of heat-resistant glass coated with a metallic oxide that's fired in for permanence. Ends are silvered so you can use clip contacts.



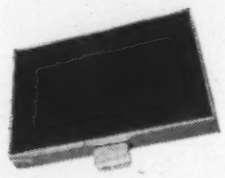
NEW, low-watt density heater from Corning consists of glass rod, coated with a metallic conductor, and having silvered ends for attaching clip contacts.

With either a 120 or 240 volt source, you have a power *output* rate of roughly 50 watts for every 6 inches of rod.

Someone described this low-watt density heater as "a non-crystalline, rigid wire made of glass." The big question: What can you do with it? So far the project development people at Corning have come up with hot rods ranging in size from 6 to 24 inches. Larger sizes are being looked into.

Seems like a compact heater like this should be good for lots of things. We await your suggestions and inquiries.

Working on the same principle of a metallic coating that conducts electricity to produce heat are panels like this.



These panels are called PYREX brand industrial radiant heaters. You'll find them in use in plants 'round the country for drying, heating, baking, curing.

Main reason for the popularity of these heaters is the kind of heat you get. It's *uniform*, and *long wave*—5 microns and over.

And long wave heat is very readily *absorbed*. For example, here's comparable performance for a white surface.

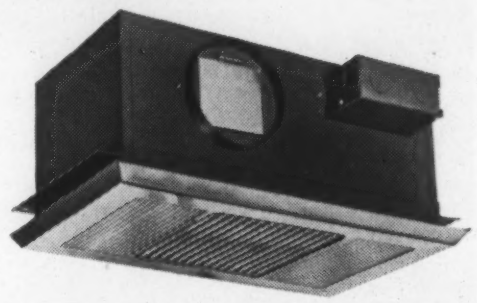
Source	Temperature °K	% radiant energy absorbed
infrared lamp	2500	30
sheathed wire unit	1000	70
"PYREX" heater	600	90

With the long wave heat from PYREX® heaters, color is of *little* importance—heating speed is almost constant.

PYREX industrial radiant heating panels are mounted in an aluminized steel frame and come complete with built-in reflector, mounting hangers, junction box, and leads.

All the facts about this efficient way to get heat are spelled out in Bulletin PE-60. Use the coupon if you'd like a copy.

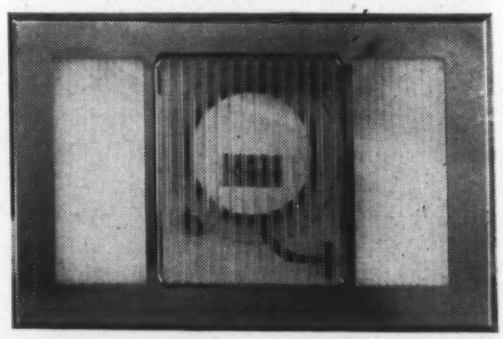
Inside job



This combination ventilator and lighting fixture is compact and smart looking. It's made by Fasco Industries, Inc., a Rochester, N. Y., firm.

Mounted in the ceiling, this fixture exhausts stale air and provides illumination for bath and/or utility rooms.

Where do we enter the picture? The grille is made of 7½"-long pieces of *glass* rod. Glass makes for smooth air flow, looks good, and stays that way.



And the 4"x7" lighting panels are Corning No. 66 Alba-lite—an opal glass in an attractive fluted pattern. Alba-lite diffuses; it stands up to the heat from the 60-watt lamps. It, too, looks good, and is easy to keep clean.

Suggestion: If anything you make (or contemplate making) uses glass parts, try Corning. You'll get *what* you want, *when* you want it, in the *quantities* you need, at a *price* that makes sense.

Or as a starter, ask for "This Is Glass." In its 64 pages you'll probably find something you can use. Remember: *Corning can do almost anything with glass.*

Corning means research in Glass

CORNING GLASS WORKS, 50-12 Crystal Street, Corning, New York

Please send me: ☐ PE-34 "Corning Flat Glasses"; ☐ PE-60 "PYREX brand industrial radiant heater catalog"; ☐ "This Is Glass"

Name..... Title.....

Company.....

Street.....

City..... Zone..... State.....

For more information, turn to Reader Service Card, circle No. 391

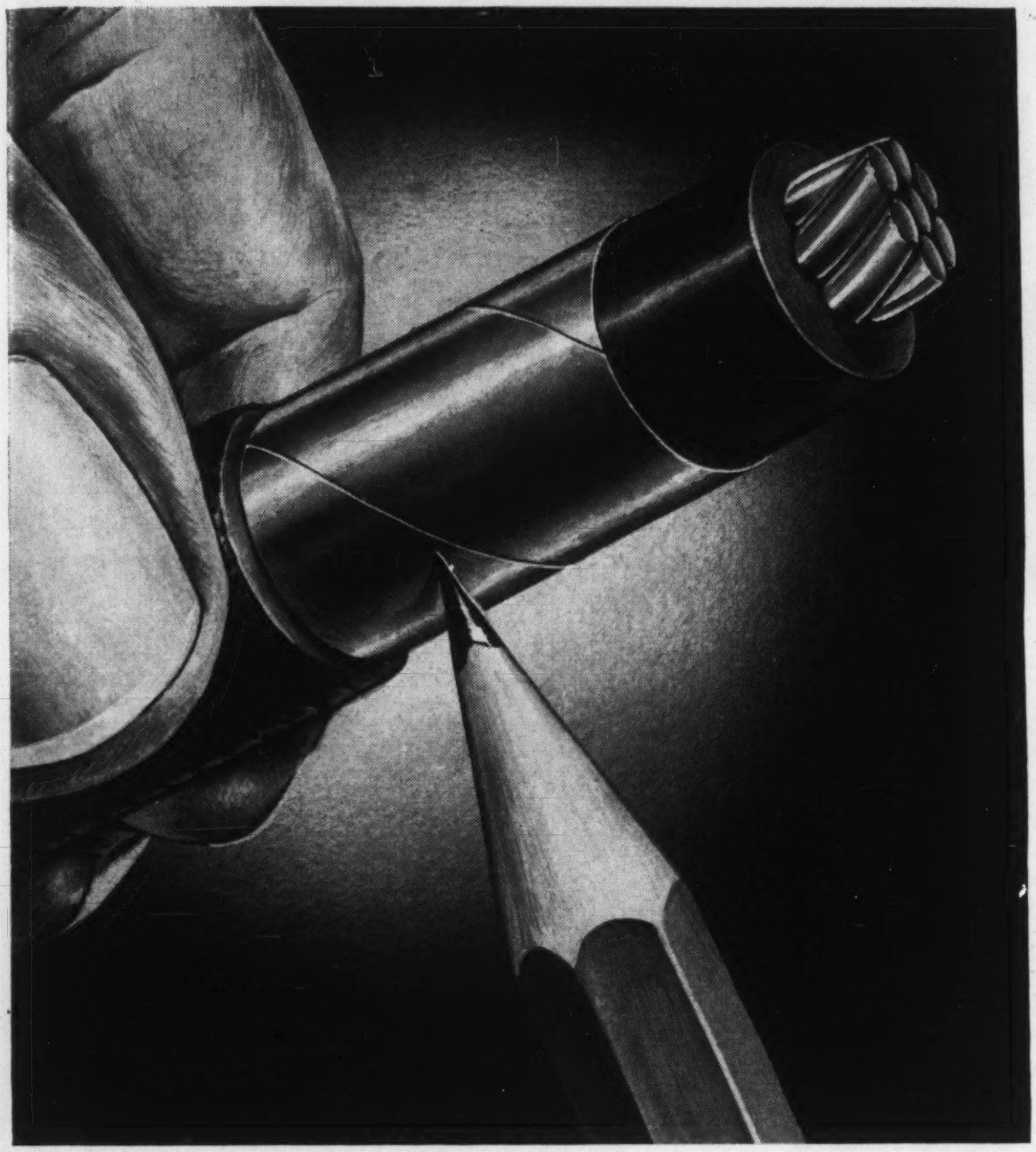
STAINLESS STEEL RESISTS CORROSIVE FUMES!

. . . And in many applications, that's a mighty important reason why designers specify it. There are other reasons, too. Stainless doesn't rust or peel. It resists heat, chemical corrosion and denting. It's strong. And its solid, durable beauty never fades, because stainless steel is the metal that comes up bright and clean with mere soap-and-water washing. For things that must *last*, and last *beautifully* — specify stainless steel. And remember — the very best stainless steels are made with Vancoram Ferro Alloys! Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N. Y. Producers of alloys, metals and chemicals.

VANCORAM

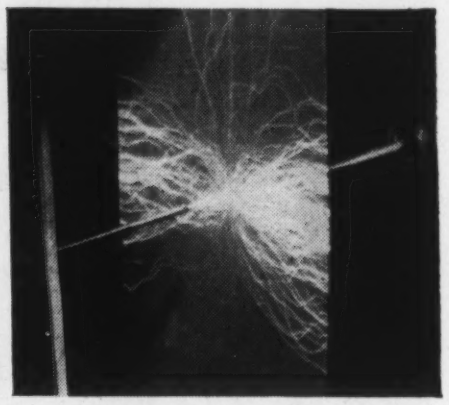
VANADIUM CORPORATION OF AMERICA

For more information, turn to Reader Service Card, circle No. 405



PROPERTIES OF "MYLAR"

"Mylar" offers a unique combination of properties that may help you improve performance and lower costs of *your* product. Here are two of the many important properties for evaluation.



HIGH DIELECTRIC STRENGTH: Average of 4,000 volts per mil . . . average power factor of 0.003 at 60 cycles.

SUPERIOR CHEMICAL RESISTANCE: Unaffected by oils, grease, most acids and alkalis, moisture and solvents.

NATIONAL ELECTRIC REPORTS...

Tapes of Du Pont MYLAR® help improve building-wire performance . . . cut manufacturing costs

PROBLEM: National Electric Products Corp., Pittsburgh, was seeking a higher-quality material to replace rubber-filled cotton tape used in their building wire. At the same time, they were looking for ways to cut manufacturing costs.

SOLUTION: Du Pont "Mylar"* polyester film. *And "Mylar" costs less on a square foot basis than rubber-filled cotton tape.* Tests proved a tape of "Mylar" immersed in water for 12 hours absorbed less than 1% of its weight vs. 32% for rubber-filled cotton tape. Building wire using 1 mil "Mylar" had 4 times the abrasion resistance of wire using 10 mil rubber-filled cotton tape.

RESULTS: Reduced wire diameter and weight. In manufacturing, "Mylar" permits additional savings because reduced cable diameter requires less braided outer covering material. The physical toughness of "Mylar" gives extra safety against damage by flexing, pinching, bending and abrasion. Resistance to moisture and normal atmospheric oxidation is improved.

HOW CAN "MYLAR" HELP YOU? Whether you use heavy duty cable, motors, transformers or miniaturized capacitors, it will pay you to investigate the performance benefits of "Mylar". Component makers find this tough, thin film often costs less on an area basis than present insulation. For detailed information, send in the coupon.

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

DU PONT
MYLAR®
POLYESTER FILM

*"MYLAR" *is Du Pont's registered trademark for its brand of polyester film.*

E. I. du Pont de Nemours & Co. (Inc.)
Film Dept., Room MM-12, Nemours Bldg., Wilmington 98, Del.

Please send booklet listing properties, applications and types of "Mylar" polyester film available (MB-11).

Application_____

Name_____ Title_____

Company_____

Address_____

City_____ State_____

For more information, turn to Reader Service Card, circle No. 393

NEW LEADED STEELS FROM RYERSON

Now, machine parts faster than ever before

NEW LEDLOY 170 TUBING

average machining speed 170 surface feet per minute

Here's the fastest-machining steel tubing ever produced —and only Ryerson has it available for immediate shipment from stock. Ledloy® 170 is a cold drawn, seamless product of low carbon analysis with .15% to .35% lead added. It promises a minimum increase of 25% in productivity of machined parts or components. Sizes range from 1″ to 2½″ O.D. with maximum ⅜″ wall thickness. Other sizes can be supplied promptly.

Part produced from Ledloy 170 Tubing for machining-comparison at National Metal Show.

NEW LEDLOY 375 BARS

average machining speed 375 surface feet per minute

This newest addition to Ryerson free-machining screw steel stocks is the world's fastest-machining steel. Assigning the figure 100 to B-1112 and using this as a base, Ledloy 375 has a machinability index of 205 plus. It rates about 64% higher than B-1113 and about 20% higher than Ledloy 300.

Ledloy 375 bars presently in Ryerson stocks include rounds in sizes from ¼″ to 1″, hexagons ¼″ to ⅝″.

Ask your Ryerson representative for complete details on these new steels. And call Ryerson for an unequaled selection of cold finished bars and tubing, including the largest stocks of Ledloy 300 (also known as Ledloy A) and Rycut® leaded alloys—the fastest machining in their carbon ranges.

MACHINING COMPARISON*
Ledloy 170 Tubing vs. Nonleaded Tubing

	Ledloy 170		MT-1015	
	Speeds	Feeds	Speeds	Feeds
Center drill	172 s.f.m.	.005″	110 s.f.m.	.005″
Form tool	172 s.f.m.	.0008″	110 s.f.m.	.0008″
Boring tool	172 s.f.m.	.007″	110 s.f.m.	.007″
Cutoff	172 s.f.m.	.0013″	110 s.f.m.	.0013″
Thread	27 s.f.m.	—	20 s.f.m.	—
Tap	18 s.f.m.	—	12 s.f.m.	—
Production time	35 seconds		49 seconds	

* As demonstrated at National Metal Show, Cleveland, 1958.

RYERSON STEEL®

Member of the INLAND® Steel Family

Principal Products: Carbon, alloy and stainless steel — bars, structurals, plates, sheets, tubing — aluminum, industrial plastics, metalworking machinery, etc.

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • WALLINGFORD, CONN. • PHILADELPHIA • CHARLOTTE • CINCINNATI • CLEVELAND
DETROIT • PITTSBURGH • BUFFALO • INDIANAPOLIS • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

For more information, turn to Reader Service Card, circle No. 484

first in silicones

Dow Corning

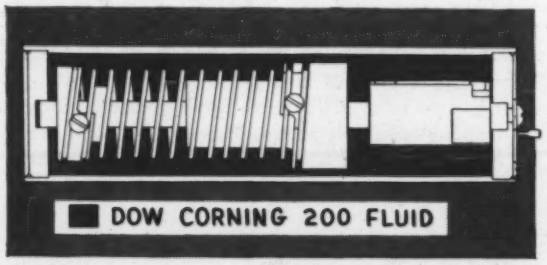
SILICONE NEWS

for design and development engineers • No. 57

ASSURE UNIFORM DAMPING, USE STABLE SILICONE FLUIDS

You can be sure of maximum stability and uniform performance when you specify silicone fluids for damping, springing or driving media. The new accelerometers developed by AiResearch Division, The Garrett Corporation, provide a good example.

With Dow Corning 200 Fluid serving as the damping medium, these spring-loaded potentiometer type accelerometers maintain a high degree of accuracy and reliability at temperatures ranging from —65 to 350 F. The accompanying table makes it easy to see why. The silicone fluid's near-constant viscosity over the operating temperature span of these units, plus excellent resistance to oxidation and to breakdown due to mechanical shear, offered AiResearch just the right combination of properties for high accuracy, low maintenance and long service life.



Available models, that range from 1g to 10g, may be substituted without need of adjusting or calibrating associated equipment—an advantage attributable to versatile Dow Corning 200 Fluid. *No. 583*

PHYSICAL PROPERTIES OF DOW CORNING 200 FLUID (50 Centistokes)

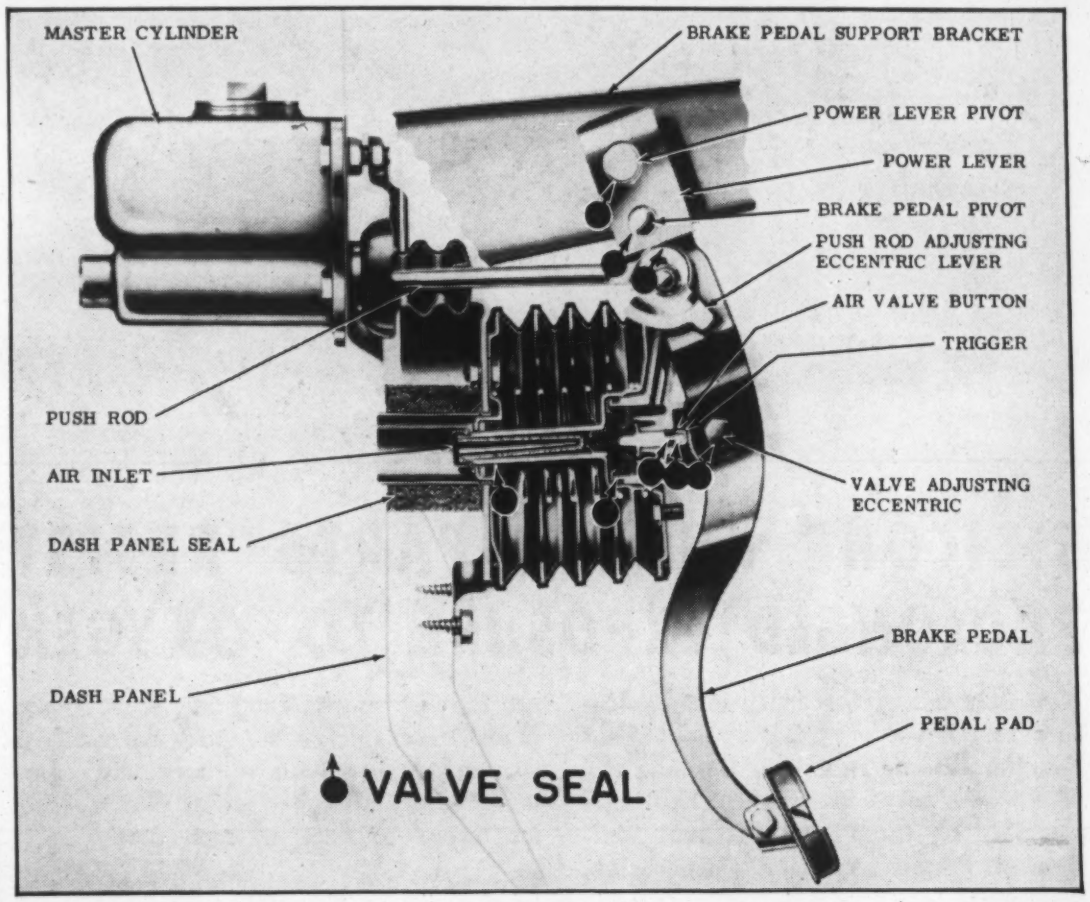
Viscosity in SSU, at 100 F	185
Viscosity-Temperature Coefficient[1]	0.59
Pour Point[2]	—67 F
Boiling Point at 0.5 mm Hg pressure	482 F
Flash Point[3], Minimum F	535
Thermal Conductivity[4]	0.00036
Coefficient of Expansion cc/cc/°C	0.00104
Surface Tension, dyne/cm	20.8
Specific Gravity, 25 C/25 C	0.960

[1] $1-\frac{V210\ F}{V100\ F}$

[2] Pour point ASTM D97-39, sections 5 to 7.

[3] Open Cup, ASTM D92-33.

[4] $\frac{g\text{-}cal}{sec \times cm^2 \times C}$ at 50 C



HOW TO LUBRICATE AND PROTECT RUBBER PARTS

What one material can you specify to lubricate rubber parts and protect them during assembly, storage and rugged service? Kelsey-Hayes engineers will tell you it's Dow Corning Valve Seal.

For over six years, Kelsey-Hayes Co. has been using this silicone compound on the rubber diaphragms and seals in its automotive power brake assemblies for trucks, buses and passenger cars. Nonreactive to both natural and synthetic rubber, a light coating of Valve Seal lubricates the parts and keeps them soft and pliable; it increases their efficiency and extends their service life.

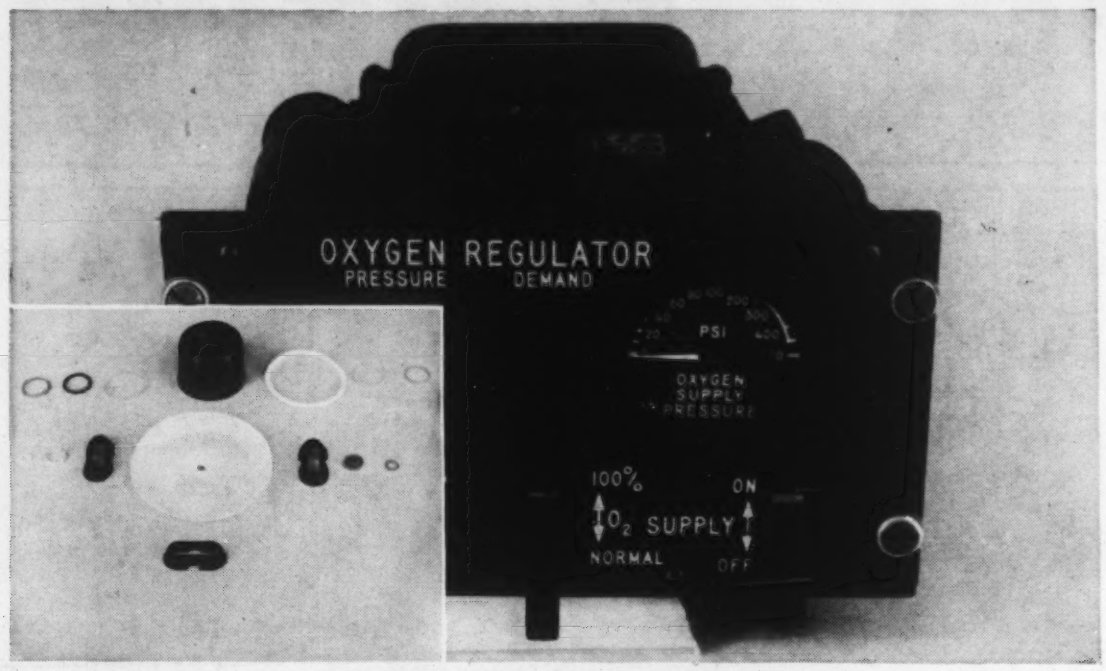
In addition, company engineers report, this silicone compound has reduced damage to the delicate rubber parts during assembly, and has made it easier to slip the parts in place.

Nonbleeding, nongumming and nonoxidizing, this silicone compound is virtually indifferent to heat or cold. As a result, it provides efficient lubricity even after long service at temperature extremes. *No. 582*

Santa Claus Gets An Assist From Silicones

They say St. Nick stops fretting over his big stock of colorful toys when his helpers discover how efficiently Dow Corning Silicones lubricate the plastic parts and keep them in good working order.

Santa's helper in this instance is Knickerbocker Plastics of Los Angeles, producer of a popular, 2-way water pistol for junior spacemen. Knickerbocker's *(Cont. Pg. 2)*



SILICONE RUBBER PARTS RESIST PROLONGED EXPOSURE TO OXYGEN

New evidence of the exceptional oxidation resistance of Silastic®, the Dow Corning silicone rubber, is the long life of Silastic parts in oxygen regulators produced by the Pioneer-Central Division of Bendix Aviation Corporation, Davenport, Iowa.

These sensitive mechanisms, which control the mixture and flow of life-sustaining oxygen to airmen at high altitudes, utilize many rubber parts for valve seats, sensing diaphragms and static seals. When made of organic rubber, they deteriorated so rapidly that both military and commercial regulations required that a service record be kept on each part.

This meant frequent dismantling of equipment to replace outdated parts — a time-consuming, costly operation. Some parts, held in storage for long periods, were scrapped even before going into service.

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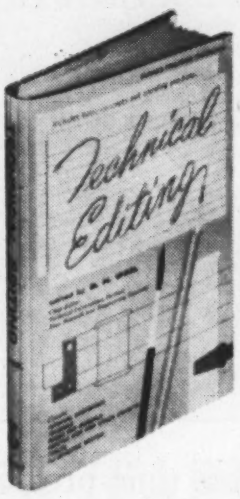

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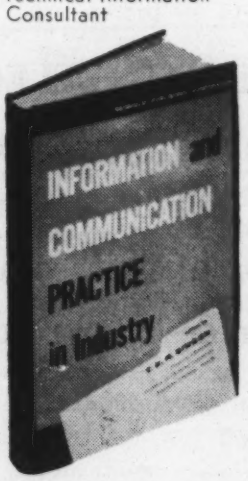

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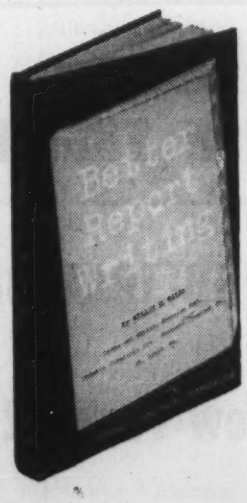

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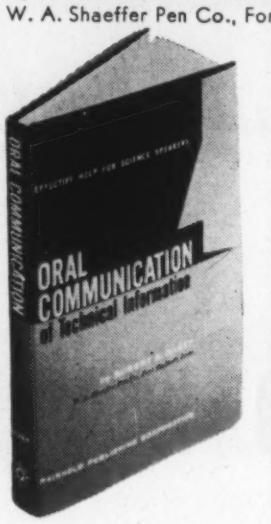

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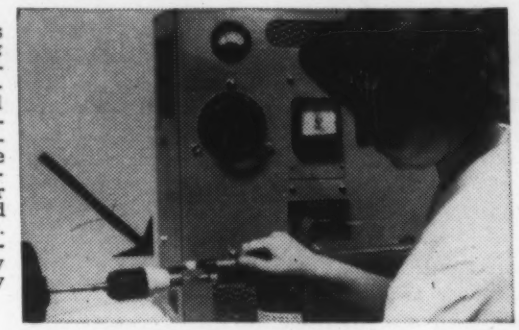

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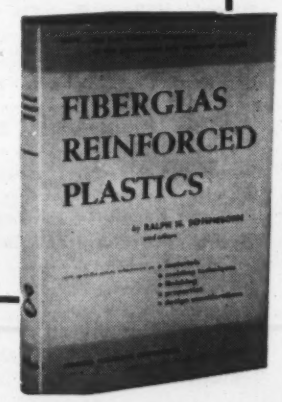

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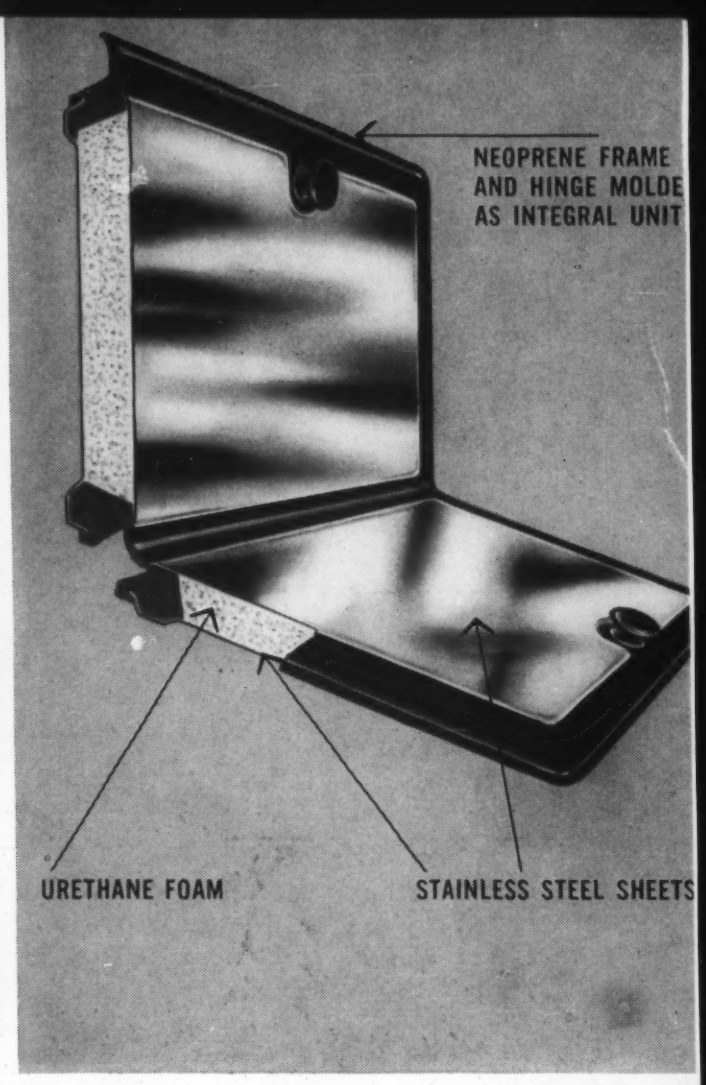

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